Report for

Buildings Commissioner Robert D. LiMandri

CTL, PC Project No. 500108

High Risk Construction Oversight Study

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A. Executive Summary

A.1 INTRODUCTION

This report provides a compilation of findings and recommendations from the New York City Department of Buildings High Risk Construction Oversight (HRCO) study that was conducted from July 2008 through January 2009.

This chapter provides an overview of the study with a discussion of overall purpose and approach. At the end is a summary of the recommendations that resulted from the study.

Following chapters discuss results from the HRCO benchmarking study and general recommendations that apply broadly to New York City construction operations. The balance of the report is devoted to the specific studies and recommendations for high-rise concrete, crane and excavation operations. The chapters on each of these operational areas reflect the specific characteristics of that area of study. Thus, while there is a general similarity among these chapters, there are also many differences in presentation that are necessitated by the differences in the approach and findings in each area.

A.2 DESCRIPTION OF THE HRCO STUDY

In July 2008, The New York City Department of Buildings (DOB) initiated the High Risk Construction Oversight study (HRCO). This was precipitated by the March 15th and May 30th fatal crane collapses as well as a general increasing trend in occurrences of job-site accidents. DOB identified three high risk areas of study based on historical accident data: high-rise concrete, cranes and hoists, and excavation operations.

The goal of this study was to develop recommendations for modifications to the NYC regulatory framework and construction industry practices to improve safety. DOB retained CTL as the lead consultant on this effort. CTL partnered with organizations specializing specific to the high risk operations: Crane Tech Solutions (CTS), AECOM, Patuxent Engineering Group, Construction Safety Consultants and DBR Group.

The HRCO study was divided into five areas: high-rise concrete, cranes, excavations, personnel and material hoists, and the Department's regulatory framework. High-rise concrete comprised buildings greater than 15 stories, which reflects the 1968 building code definition. However, the recommendations are intended to apply to buildings greater than 10 stories, which is the high-rise definition in the 2008 building code.

The HRCO study included:

Site Observations: Systematic review of procedures on construction sites associated with high-risk operations.

Review of DOB Operations: Study of DOB's regulatory framework, permitting procedures, field inspections and staffing.

Industry Outreach: Site observation teams gathered feedback from construction crews at the selected construction sites on industry and DOB issues and conducted formal meetings with industry.

Benchmarking: Review of procedures and requirements of other jurisdictions.

The purpose of these activities was to identify patterns in the construction process associated with opportunities to improve safety. Thus, for example, site visits and permitting reviews were conducted to identify occurrences of safety issues common to multiple projects rather than exhaustively study safety aspects of any one specific construction project. A formal protocol was established at the onsite of the study by which HRCO field teams alerted DOB of potential safety issues for DOB response and enforcement as necessary.

Each operational team (high-rise concrete, cranes, excavations and hoists) included a principal and a field manager. The team principal was responsible for overall technical execution of the assessment of the operational area. The team field manager was responsible for oversight of the day-to-day operations of the site observation teams, including assessment of DOB operations. The lead staff for the HRCO study are shown in Table A.1.

Table A.1: HRCO consulting team organization and lead staff.

Project Management: CTL	
Steven Smith, Ph.D., P.E.	Program Director
W. Gene Corley, Ph.D., P.E.	Senior Program Advisor
High-Rise Concrete: CTL	
Jeffrey Garrett, Ph.D., S.E.	Principal
David Drengenberg, P.E[1].	Field Manager
Cranes: Crane Tech Solutions (CTS)	
Manfred Kohler, D. Eng. Frank Hegan	Principals
Marcus Janik, D. Eng.	Field Manager
Excavations: AECOM	
Ted Bushell, P.E. [1]	Principal
Darren Diehm, P.E. [1]	Field Manager
Hoists: Patuxent Engineering Group	
John O'Connor, P.E. [1]	Principal
Brian O'Connor	Field Manager
Site Safety: Construction Safety Consultants	
Larry Naro	Principal
Regulatory Operations: DBR Group	
Dennis Richardson, P.E. [1]	Principal

[1]Registered in a state other than New York

The participating firms of the study provided expertise in each of the high-risk areas. CTL staff investigated some of the most important construction accidents and failures of recent history, and are leaders in concrete building construction. For example, CTL senior advisor, W. Gene Corley, served as the Team Leader for the FEMA study of the World Trade Center attacks. The excavation team (STS/AECOM) provides excavation consulting services on some of the most challenging projects around the world, including record-setting high-rises such as the Chicago Spire. Crane Tech Solutions has decades of experience in crane design, inspection, maintenance and leasing services. Patuxent Engineering Group is one of only a handful of firms providing consulting expertise in temporary structures including construction hoists. DBR Group provided experience to critically assess the NYC regulatory framework. DBR Group principal, Dennis Richardson, is a past building official and active member of building code committees.

In all, a staff of more than thirty experts participated in the study. Most principals are presidents and CEOs with decades of experience in their respective fields. The HRCO experts have practiced throughout the United States, both in New York City and outside. The teams' broad geographical range of experience provided a useful perspective to compare and contrast New York City construction practices with those prevailing in other dense urban areas that face similar public safety challenges.

A.3 STATISTICAL ASPECTS OF THE HRCO STUDY

The HRCO study utilized statistical procedures to the greatest extent possible. Table A.2 provides a summary of historical DOB data related to construction operations. *Incidents* include any event at a job site that required DOB response and *accidents* are those incidents that caused injury, fatality or significant property damage. The high risk columns provide subtotals for high-rise concrete, cranes, excavations and hoists. As can be seen, the operations identified as high risk account for approximately 1/3 of accidents and ½ of fatalities. Additionally, the rate of injuries and fatalities per accident is typically higher for these four types of operations.

	High-rise Concrete	Cranes	Excavation	Hoists	High Risk	All Other	Total	High Risk %
Incidents	141	73	138	39	391	878	1269	31%
Accidents	63	23	19	18	123	246	369	33%
Injuries	68	52	22	31	173	269	442	39%
Fatalities	6	12	2	6	26	24	50	52%

Table A.2: HRCO review of DOB incident database (data from January 2, 2006 to January 13, 2009)

Statistical aspects for each operational area are discussed in those chapters of this report. In general it must be recognized that the HRCO study, while substantial and methodical, was still limited to a relatively brief period of time (August – December, 2008) and a limited cross section of the NYC construction environment. Additionally, accidents associated with construction are generally indeterministic (random events that cannot be predicted with certainty) and are a function of human factors, materials, and equipment. In many instances the study relied on extrapolation and empirical assessment of observations. Results are based on the most well-considered assessment possible utilizing limited and variable data combined with the professional experience of the team and input from DOB and Industry.

The method used to preliminarily assess viability of the study is as outlined in ASTM E122 - Standard Practice for Calculating Sample to Estimate, With a Specified Tolerable Error, the Average for a Characteristic of a Lot or Process. This procedure provides a basis for determining meaningful sample sizes for indeterminate processes such as NYC construction operations. Table A.3 provides examples of sample size calculations.

Table A.3: Sample Size Calculations per ASTM E122.

Population probability	0.05	0.10	0.30
Error in estimating population probability	0.10	0.10	0.10
Probability of exceeding error	0.05	0.05	0.05
Minimum sample size	18	35	81

The interpretation of Table A.3 is as follows:

1. **Population probability** is the rate of occurrence of a specific defect. For example, the percentage of construction sites that might exhibit a fall hazard.
2. **Error in estimating population probability**, relative to the example above this is the error in estimating the percentage of occurrences of fall hazards. In Table A.3 this is taken uniformly as 10% (thus the actual occurrence of fall hazards would be within 10% of the expected probability).
3. **Probability of exceeding error**, allows for the potential that the actual error will be greater than specified in item 2.
4. **Minimum sample size**, based on the acceptable error rates described above, this is the minimum sample size to properly observe the specified defect.

A rigorous application of this method to every facet of the high risk operations is not practical. However, relative to the “defect rates” that were observed in NYC, ASTM E122 indicates that the number of site observations conducted during the HRCO study were of reasonable order to characterize the operations. Summaries of site observation totals and geographical distribution are provided in Table A.4 and Figure A.1.

Table A.4: Summary of HRCO Site Observation Totals.

Operational Area	**Site Observations** (includes repeat visits)	**Distinct Sites**
High-rise Concrete	181	94
Cranes	182	104
Excavations	174	144
Hoists	99	90
Total	636	432

For example, the fall hazard risk of not tying-off was observed at 31% of high-rise concrete sites. Going back to table A.3 shows that approximately 81 site observations would be necessary to properly observe a defect that occurs at this rate, and with the specified error limits. Thus the HRCO total of 181 site safety site visits at 94 unique sites (see High-rise Concrete chapter) should be sufficient to characterize tie-off violation issues.

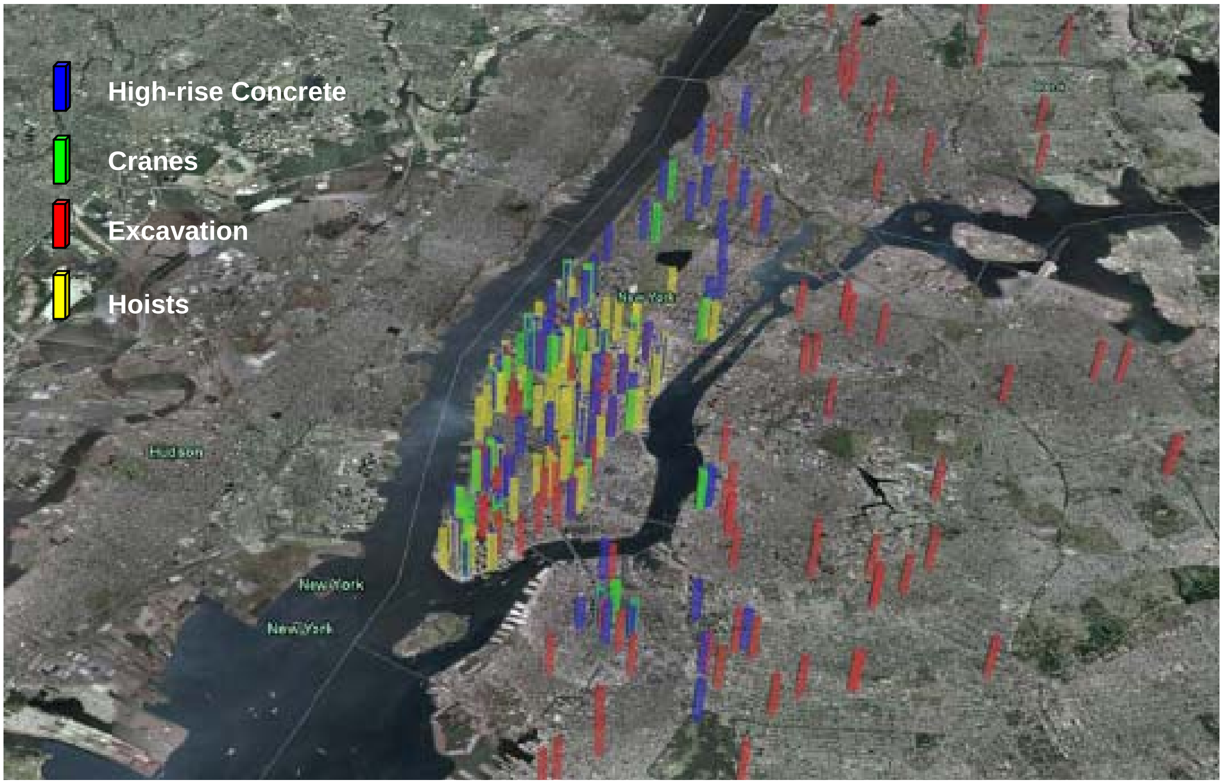

Figure A.1: Distribution of site observations.

A.4 INDUSTRY OUTREACH

The general approach of engaging industry was similar and two-phased among the operational teams (high-rise concrete, cranes, excavations and hoists). One primary method of industry outreach was accomplished at job sites, by gathering feedback from construction staff. The other method was through formal subcommittee meetings with a cross-section of industry stakeholders.

In addition to these two methods each operational team conducted other forms of outreach as guided by particular aspects of the study (e.g. the high-rise concrete team observed operations at a union training facility). Major industry meetings conducted as part of the study are presented in Table A.5.

Table A.5: HRCO Industry Outreach Meetings.

Operation Areas	Date	Description
High-rise Concrete and Excavations	Nov. 18, 2008	Kick-off meeting with industry stakeholders.
High-rise Concrete	Dec. 15, 2008	Construction quality meeting.
	Dec. 18, 2008	Concrete industry subcommittee meeting #1.
	Jan. 20, 2009	Concrete industry subcommittee meeting #2.
Cranes	Oct. 16, 2008	International crane symposium.
	Nov. 7, 2008	Crane industry roundtable.
	Dec. 15, 2008	Crane industry subcommittee meeting #1.
	Dec. 16, 2008	Crane manufacturer meeting.
	Jan. 8, 2009	Crane industry subcommittee meeting #2.
	Jan. 21, 2009	Crane industry subcommittee meeting #3.
Hoists	Dec. 18, 2008	Hoist industry subcommittee meeting #1.
	Jan. 13, 2009	Hoist industry subcommittee meeting #2.
Excavations	Dec. 15, 2008	Excavation industry subcommittee meeting #1.
	Jan. 13, 2009	Excavation industry subcommittee meeting #2.
All	Feb. 3, 2009	*Buildsafe* seminar with breakout sessions for each operational area.

Industry subcommittees were formed by soliciting participation from professionals, and, in the case of cranes, major manufacturers. Each operations group conducted at least two monthly meetings. The first meeting was primarily devoted to presentation of developing recommendations. Follow up meetings were focused on refining the final recommendations. Relevant source data (as available) and draft summaries were provided in advance of the meetings to industry and DOB. Subcommittee participants were invited to comment on interpretation of the presented data; individual experiences; scope and content of the proposed recommendations; feasibility of implementation; and, perceived effectiveness and anticipated compliance with the potential recommendations. Participants were also encouraged to suggest alternative or supplemental recommendations based on knowledge of local practice and experience with the existing regulatory process. Participating stakeholders are shown in Table A.6.

Table A.6: HRCO Industry Stakeholders.

High-Rise Concrete	Cranes and Hoists		Excavations
Concrete Industry Board	Alimak Hek, Inc.	Morrow Equipment Company	Bronzino Engineering
Bovis Lend Lease	ALL Safe LLC	North Side Structure Steel Institute of NY	BTEA
BTEA	AMG Engineering	Perimeter Bridge & Scaffold Corp.	Desimone Consulting
Casino Development Group	Atlantic Hoisting and Scaffold	Plan B Engineering	Foundations Group
DCP	Bay Crane	REBNY	General Contractors Association of NY
Desimone Consulting	BTEA	Regional Scaffolding	John Civetta & Sons, Inc.
DiFama Concrete	Building Contracting Assoc.	Rockledge Scaffold	LMW Engineering
Flint Lock Construction	CAGNY	Steel Institute of NY	Local 780
Foundations Group	Carpenters Local 1536	Stroh Engineering Services	Mueser Rutledge
Howard I Shapiro & Associates	Colgate Scaffold	Tadano Cranes	Pillori Associates
Local 46	Favelle Favco Cranes USA Inc	Terex Cranes Wilmington, Inc.	RA Consultants LLC
Narov Assoc/ALEC	Howard L. Shapiro & Associates	TES Inc	REBNY
North Side Structures	Liebherr-Werk Biberach	The Cement League	Urban Foundation Engineering
Port Authority of NY & NJ	Lift Tech Elevator	Thyssen Krupp Safeway	
REBNY	Linkbelt Construction Equipment Company	Tishman	
SEAoNY	Local 1	United Hoisting & Scaffobling Corp.	
Tectonic Engineering	Local 14 (Operator's Union)	Universal Builders Supply (UBS)	
The Cement League	Local 46 Metallic Lathers Union	US Dol OSHA	
Thornton Tomasetti	Manitex	Valjato Engineering	
Urban Foundation/Eng LLC	Manitowoc		
US DOL OSHA			
WSP Cantor Seinuk			

A.5 SUMMARY OF RECOMMENDATIONS

The culmination of the HRCO study was development of more than sixty recommendations to improve safety during high-risk construction operations. Separate chapters for each operation detail the development and content of these recommendations. Below is a table summarizing all of the recommendations. The table includes each recommendation name and ID, a paraphrase of the recommendation language, a key observation associated with the recommendation and identification of *further study* items. The recommendation ID uses HC (high-rise concrete, C (crane), E (excavation) and H (hoist). *Further Study* recommendations, as the designation implies, are those for which there is clear indication safety improvements are possible, but specific and necessary details of the recommendation require additional study. The *key observation* provides a single example of the supporting data to provide a degree of context for the recommendation.

Recommendations that are not identified as Further Study may still require analysis or alteration as they are being implemented. And all recommendations, whether or not Further Study, should be subjected to on-going review after implementation to assess whether the desired affect is being achieved.

It is important to appreciate that this study was motivated by construction accidents and had the sole purpose of generating recommendations for changes to construction operations and regulatory practices to improve safety. Thus, by its very nature, the focus of the study was to identify areas in which there is opportunity for significant improvement.

New York City is a dynamic and challenging environment in which to undertake construction. Many of the leading design and construction companies in the world have sole or primary practices in New York City. Thus, the HRCO team did not lightly take on the task of providing these recommendations. In a number of instances the recommendations were generated by observing positive practices that are already in place by many in the industry and recognizing that the practice should be adapted universally.

Lastly, the HRCO team recognizes that a number of recommendations apply beyond the subject operational area. This is particularly relevant, for example, regarding site safety and fall hazard recommendations. These were motivated by high-rise concrete accidents, but similar risks occur with steel and masonry construction. The degree and manner in which recommendations should be applied to other construction operations should be carefully considered as the recommendations are implemented.

High-Rise Concrete - Formwork

HC-1	**Formwork Design Requirements**	
Require essential specification information to be included on stamped formwork designs. Key Observation: 45% of critical formwork defects attributable to design.		
HC-2	**Protection of Existing Construction**	
Require thresholds for the production of stamped and sealed formwork designs to include instances where adjoining structures are used to support formwork. Key Observation: Recent occurrences of concrete construction causing failures in adjoining buildings.		
HC-3	**Formwork Special Inspection**	
Require Regular special inspection of formwork and reshore installations. Key Observation: 79% of critical formwork defects attributable to construction.		
HC-4	**Formwork Lateral and Wind Load Design**	
Clarify existing wind design requirements in conformance with national design standards. Key Observation: Five incidents of wind-induced formwork failures since 2006		
HC-5	**Formwork Construction for Wind Resistance**	
Require formwork decking to be positively secured against uplift. Key Observation: Majority of respondent municipalities utilize wind resistant engineered modular formwork.		
HC-6	**Wind Monitoring**	**Further Study**
Require continual monitoring of actual wind conditions. Key Observation: Available remote wind data is not a sufficient surrogate for site-specific conditions.		
HC-7	**Wind Tunnel Studies**	**Further Study**
Perform wind tunnel studies to better understand the effect of wind on formwork assemblies. *Key Observation: Available references on the subject are limited.*		

High-Rise Concrete – General Site Safety

HC-8	**DOB Inspector Qualifications**	
Augment current DOB inspector training regimens to mirror industry expertise. Key Observation: Inspector knowledge base regarding safety is critical to credibility of department.		
HC-9	**DOB Inspection Procedures**	
Update and maintain sets of inspection protocols. Key Observation: Non-uniform enforcement is the most common industry criticism of Department of Buildings.		
HC-10	**Housekeeping Requirements**	
Clarify specific housekeeping requirements. Key Observation: Falling debris is one of the most commonly reported incidents.		
HC-11	**Site Safety Hierarchy**	**Further Study**
Remove conflict of interests with respect to site safety personnel. Key Observation: Field observations indicate site safety personnel are hampered by potentially conflicting lines of accountability.		
HC-12	**Upgrading Netting Requirements**	**Further Study**
Study Effectiveness of enhancing existing netting requirements. Key Observation: Over 200 material fall incidents reported between January ’06 and June ‘08		
HC-13	**Material Handling**	**Further Study**
Establish requirements for the use of outrigger systems for material handling. Key Observation: Current material handling practice creates significant fall hazards at building edges.		

High-Rise Concrete – Worker Falls

HC-14	**Fall Hazard Awareness**	
Implementation of a fall hazard awareness campaign. Key Observation: Workers failed to adequately tie off at 31% of visited sites.		
HC-15	**Contractor Documentation**	**Further Study**
Require contractor to document remedial actions taken after safety violations. Key Observation: Worker falls account for 66% of all fatalities on concrete construction sites.		
HC-16	**Repeat Offense Enforcement**	**Further Study**
Require mandatory site shut down after reaching a specific violation count threshold. Key Observation: Statistical analysis indicates existing enforcement practices are not correlated with reduced numbers of safety violations.		

High-Rise Concrete – Special Inspections and Construction Quality

HC-17	**Special Inspection Rule**	
Enforce that all special inspectors conform to updated NYC code requirements. Key Observation: Construction quality violations were documented at more than half of all visited sites.		
HC-18	**Field Inspection**	
Enhance inspector training to include construction quality issues such as field testing of concrete. Key Observation: Current inspector expertise does not include construction quality issues.		
HC-19	**Inspection of Testing Labs**	
Enhance DOB staff training to include laboratory testing procedures and requirements. Key Observation: Testing laboratory observations indicated pervasive non-conformance with code requirements.		
HC-20	**Reinforcing Bend Quality Assurance**	
Require documentation of proper bar bending procedures. Key Observation: Critical construction quality issues were observed at a quarter of all visited sites. Improper bar bending procedures are a significant contributor to this defect rate.		
HC-21	**Reinforcing Placement Quality Assurance**	
Require documentation of proper bar placement procedures. Key Observation: Critical construction quality violations were observed at a quarter of all visited sites. Improper bar placement is a significant contributor to this defect rate.		

High-Rise Concrete – Plan Review

HC-22	**Monitoring of Peer Review**	
Recommend the retention of professional engineers to supervise the peer review process. Key Observation: Majority of responding municipalities perform detailed structural review.		
HC-23	**Structural Drawing Information**	
Require minimum levels of structural information to be included on drawings. Key Observation: Not all sets of structural drawings contain sufficient levels of design information.		
HC-24	**Monitoring of Structural Information Quality**	
Recommend the retention of professional engineers to review drawings for minimum levels of structural information. Key Observation: Many responding municipalities utilize engineering staff to review plan submissions for structural issues.		
HC-25	**Monitoring Constructability**	
Recommend the retention of professional engineers to review drawings for constructability. Key Observation: Many responding municipalities utilize engineering staff to review plan submissions for structural issues.		

Excavations

E-1	**Excavations at Footings**	
Requirements for Excavations at Footings to Protect Adjacent Structures. Key Observation: Standard geotechnical practice that is not enforced in NYC by code or convention.		
E-2	**Permitting of Underpinning**	
Revisions to underpinning permitting to better screen for safety issues. Key Observation: Nearly 88% of jurisdictions stated that a detailed or partial technical review was performed on permit applications for permanent systems. The recommendation is intended to provide a sorting mechanism to allow DOB to prioritize the most technically challenging submittals for review.		
E-3	**Preconstruction Surveys**	
Preconstruction survey requirements to better define condition of neighboring structures. Key Observation: 18% of Contractors (or Site Contacts) could not verify that a preconstruction survey was performed prior to construction. Of those that responded that a survey was done, only one could produce a copy of the assessment report for HRCO review.		
E-4	**Monitoring During Excavations**	
Requirements to better monitor the effect of excavation operations on neighboring structures.. Key Observation: 21% of the sites had damage to adjacent structures (settlement or visibly discernable distress) which could be attributed to earth retention and/or underpinning operations		
E-5	**Minimum Drawing Standards**	
Recommendations for minimum content on design submittals to sufficiently convey critical information. Key Observation: Inadequacies (ranging from minor elevation issues to potentially un-constructible details) were identified in approximately 46% of the drawings available for review by the HRCO		
E-6	**Limited Technical Review**	
Require pre-permit technical review of excavation design. Key Observation: The current Department of Buildings practice of submittal reviews based on fire, egress, and zoning will not capture technical deficiencies or incomplete subgrade site designs.		
E-7	**Underpinning Notification**	
Require advanced notice of underpinning operations to DOB to improve inspection rates Key Observation: Based on the available permit filing data, active sites (defined as a contractor on-site and available access) were identified by the HRCO at a rate of 40 to 45% - active underpinning was observed at only 11 sites.		
E-8	**TR1 and Inspection Log**	
Enhancements for TR1 and inspection logs to improve oversight and accountability Key Observation: Inadequate construction or variation from permitted design was identified at approximately 36% of sites with earth retention systems and 26% of sites with underpinning.		
E-9	**On-Site Meetings**	
Preconstruction onsite meeting with contractor, designer and special inspector to improve coordination. Key Observation: 35% of the Contractors (or other Site Contacts) could not identify the Special Inspector. Of those that could identify the Special Inspector, less than 50% could provide the date of the last site visit.		

Crane – Equipment Design

C-7	**Approved Manufacturer**	
Replace the current model-specific Certificate of Approval process with one that approves the manufacturer using predetermined, industry-standard criteria. Key Observation: Reviewing designs of modern cranes is not feasible.		
C-14	**Older Equipment**	
Require an extensive mechanical crane inspection every 10 years for all cranes and potentially an age limitation for operation in the jurisdiction. Key Observation: 41% of tower and 10% of mobile cranes are older than 20 years and 23% of tower and 9% of mobile cranes are older than 30 years.		
C-21	**Electric Tower Cranes**	**Further Study**
Have an all-electric tower crane fleet in the jurisdiction by a specified date. Key Observation: Replacing diesel cranes with electric will have many cascading benefits by modernizing the fleet.		
H-1	**Hoist Equipment Acceptance**	**Further Study**
Create and implement an Equipment Acceptance Certification program for hoisting equipment employed in the NYC area. Key Observation: There is no current method to restrict the increasing use of “cloned” hoist equipment.		

Crane – Site Specific Design

C-8	**Tie-Ins**	
Tie-In connections should be subjected to special inspection and require improved design and erection procedures. Key Observation: 71% of reviewed plans did not have an engineering review of the loads imposed on the building.		
C-9	**Foundations**	
Foundations should be subjected to special inspection and require improved design and erection procedures. Key Observation: Foundations are typically poured prior to a plan review by the Cranes and Derricks division making it difficult to determine if the foundation was installed as designed.		
C-15	**Load Tests**	
The test weights to be used should not exceed the manufacturer's specification or, in case where the manufacturer is not available, the applicable ANSI standard should be used. Key Observation: 38% of reviewed load test procedures provided a test that could have overloaded the crane, and DOB inspectors have allowed such occurrences based upon the submitted procedure.		
C-5	**Counterweights**	
Counterweight information should be readily available on the drawing and on the counterweight module itself. Key Observation: 93% of observed tower cranes did not have all counterweight modules labeled for easy reading and 15% of the movable counter weight mechanism required maintenance.		
H-2	**PE Sign-Off (Hoists)**	
Require the building engineer of record or an engineer acceptable to DOB to review that the building can support the loads imposed by the hoist. Key Observation: 73% of hoist machines had no indication of an engineering review of loads imposed on the building.		

Crane – Crane Operations

C-4	**Rigging Safety**	
The city should increase enforcement of current regulations related to rigging practices, eliminate the practice of "side pulling" loads and improve rigger training courses. Key Observation: Multiple and diverse occurrences of dangerous rigging operations.		
C-12	**Articulating Boom Crane**	
The definition of "crane" should be changed so that articulating boom cranes are regulated as other cranes. Key Observation: Five of six cranes observed had issues with set up, rigging and/or operations.		
C-13	**Crane Erection**	
All assembly, climbing and dismantling of a tower crane must include the on-site participation of a Technical Advisor. Key Observation: Operational issues identified at 40% of assembly/climbing/disassembly activities.		
C - 1	**HMO C Licensure**	
Require National Crane Operator Certification for Hoisting Machine Operator "C" License Examination and Evidence of Fitness for Duty Key Observation: Many major jurisdictions moving to recognized national organizations to provide consistent crane operator certification.		
C - 23	**HMO A and B Licensure**	
Require all Hoist Machine Operators (HMOs) to have a nationally recognized certificate and ensure each operator has the necessary experience to operate the cranes they use. Key Observation: Many major jurisdictions moving to recognized national organizations to provide consistent crane operator certification.		
C - 24	**Scaffolding Hoist**	**Further Study**
DOB should require a plan review and inspection of custom built hoisting systems that are able to hoist loads exceeding 1 ton (907 kg) Key Observation: These hoists typically are not subject to a plan review or formal inspection.		
H - 3	**Riding on Top of Cars**	**Further Study**
Restrict actions of workers riding on top of cars to limit inherent dangers of working on and in close proximity to moving equipment Key Observation:		

Crane – Inspections

C - 3	**Third Party Inspection**	
Allow third party inspectors to perform the required annual crane inspections needed for the CD permit. Key Observation: The use of PLCs, the pressure to innovate their products and niche markets requiring specialized machines increases complexity and requires constant training for crane inspectors.		
C – 2	**Bolted Connections**	
All bolted connection must be checked regularly. Crane maintenance personnel must have basic knowledge of bolt torquing. Key Observation: 20% of tested bolts were loose.		
C-17	**Tracking Mobile Cranes**	
Require DOB notification prior to use of a mobile crane on a job site. Key Observation: The listed crane is available for inspection on only 10% of job sites.		
H - 4	**ANSI Standards**	
Adopt the ANSI A10.5 Material Hoist standard. Regularly update regulation to reflect current versions of A10.5 and A10.4 (Personnel Hoist standard). Key Observation: There is no national standard in NYC for material hoists.		
H - 5	**Qualified Inspections**	
Introduce a “Qualified Hoist Inspection” program that establishes the requirements and qualifications of the inspectors and inspection criteria. Key Observation: Less than 10% of hoists had been properly inspected during required “drop test”.		

Crane – Maintenance and Repair

C - 6	**Maintenance and Repair**	
The Owner must notify DOB of all major structural repairs. Parts and procedures should meeting manufacturer requirements. Key Observation: No current method to confirm that crane repairs restore crane to proper working condition.		
Increase the written maintenance and inspection log requirements to provide more complete records of the work performed on each crane Key Observation: 57% of the issues observed on cranes were related to maintenance and repair.		
C-20	**Component Tracking**	
DOB should institute a tracking system for the major structural components. Key Observation: There are manufacturers of crane replacement parts that have no authorization or technical support from the original crane designer and manufacturer.		
C-22	**Data Recorder - "Black Box"**	**Further Study**
Based upon further study, DOB should consider the use of data recording devices that will provide critical information regarding the operation of cranes within the jurisdiction. Key Observation: Without such technology neither DOB nor owner knows the actual service demands placed on the crane.		
H - 6	**Off-site Controls**	**Further Study**
Introduce and implement an Off-site Hoist Equipment Control Program to check that the equipment is adequate for the intended use. Key Observation: 30-year old hoist masts had almost 30% loss of thickness due to corrosion and wear.		
H - 7	**On-Site Log Book**	
Require that all site locations maintain an On-Site Hoist Equipment Log to standardize record keeping of all pertinent data Key Observation: Less than 20% of sites maintain any type of hoist maintenance or inspection records.		

Cranes – Department of Buildings' Operations

C - 11	**Inspector and Examiner Training**	
Assess the various skill sets of the inspectors and plan examiners of the Department of Buildings and provide them the necessary training and tools to complete their tasks effectively and efficiently. Key Observation: The importance of training (for both DOB and industry workers) was highlighted by almost every stakeholder group as a leading factor of crane safety.		
C-18	**Accident Investigation**	
The Crane and Derrick Division should augment and audit its incident/accident reporting procedures Key Observation: Improved accident documentation will provide better basis for assessing trends of safety issues.		
C-19	**DOB Self Auditing**	
Develop and install a change process whereby the Cranes and Derricks Division of the Department of Buildings monitors itself and makes adjustments as necessary. Key Observation: The Cranes and Derricks Unit (C&D) underwent a major restructuring in the past year and must now critically assess its accomplishments and areas that require improvement.		
C - 16	**RS 19-2 Revisions**	
DOB should revise of RS 19-2 and seek industry comments. Key Observation: The RS19-2 presently does not reference ASME B30.3 and B30.22 standards (the leading US standards for tower cranes and articulating boom cranes)		
H-8	**Hoist Regulation**	**Further Study**
Hoist equipment (Personnel and Material Hoists and Back-Structures) should be subjected to engineering review, permitting and site inspection by a dedicated DOB department Key Observation: There is no centralized and comprehensive approach to hoist regulation.		

B. High-rise Concrete

B.1 INTRODUCTION

This chapter summarizes the high-rise concrete construction assessment, and includes this introduction (Section 1), methodologies used to conduct the assessment (Section 2), studies and observations completed in addition to the assessments (Sections 3 and 4), and a summary of the recommendations (Section 5). CTL principally authored this chapter.

The High Risk Construction Oversight (HRCO) Team encountered great interest and desire on the part of the construction industry to increase safety on active construction sites. At the same time, during the observation of day-to-day construction operations throughout New York City, it became clear that there is substantial need for changes in the current construction practices and behaviors to actually achieve an increase in site safety. As with the NYC construction industry's past efforts to establish an awareness that hard-hats must be worn on construction sites, a program that required a committed long-term campaign, there are many facets of the construction process which will require a targeted, disciplined approach to actually achieve the universally agreed goal of improved safety. This is true of nothing so much as the need to greatly improve the current practice regarding fall protection. In this case there are sufficient regulations in place, but compliance is poor. Penetrating and changing this aspect of construction culture will require resolve by DOB and industry.

A primary theme that became apparent during this assessment is the need for modernization in the construction processes utilized in New York City by contractors. For example, modernization of current formwork practices could improve at least three safety issues: personnel fall hazards; material fall hazards; and, the structural integrity and safety of the formwork. Personnel fall hazards are associated with the labor-intensive nature of formwork construction and stripping, much of it needing to occur near the building edges, and the efforts required to provide effective fall restraints near these edges. Material fall hazards are related to the significant amount of loose material that is kept on the construction floors. Structural integrity is associated with the importance of designing and constructing the formwork to support substantial loads from wet concrete and the challenge of providing proper inspection.

Each of these three safety issues is made more challenging by the wide-spread use of stick-built forms in New York City. By comparison, the overwhelming majority of municipalities surveyed by the HRCO use prefabricated concrete forming systems for major projects[1]. Prefabricated forms offer advantages of built-in anchorage systems, more efficient control of on-site materials, and more uniform structural integrity. This is not to say that stick-built formwork can not be used safely, but it must be recognized that this outmoded forming system serves more to impede than promote safety.

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[1] See Formwork Recommendations

In similar ways modernization applies to the procedures utilized during construction inspection, concrete reinforcing steel fabrication and placement, documentation of field changes and monitoring of site safety.

B.2 SITE OBSERVATION

A total of 279 site observations were completed by HRCO field teams between August and November 2008. The two-person observation teams typically consisted of an Engineer and Safety Expert. *Targeted* site visits were limited to safety issues only. *Full* site visits included safety and engineering observations. A member of the DOB Building Enforcement Safety Team (BEST) accompanied the HRCO observation teams during a substantial number of site visits.

Sites were selected, and visited randomly, from a list of addresses with permit applications for concrete-framed buildings filed after January 1, 2008, and therefore likely to be actively engaged in construction activity (i.e.; an active site). The entire population of "Major"[2] buildings was selected from this list. In addition to these Major buildings, the HRCO observation teams visited the site of a limited number of other buildings[3]. Site observation data is summarized below. Detailed site observation summaries are provided in Appendix B.1.

Table 1: Active Site Visits[4]

	Targeted Site Visits (Safety Only)	**Full Site Visits (Safety and Engineering)**
Total Visits	181	98
Visits by Boro.	145 Manhattan 36 Brooklyn	82 Manhattan 16 Brooklyn

[2] At the time of observation, the 1968 NYC Building Code definition was used (structures exceeding 15 stories, heights of 200', or footprint areas of 100,000 SF).

[3] Buildings with fewer than 15 stories

[4] Includes multiple random repeat visits at particular addresses

Table 2: Distinct Site Observations at Active Sites

	Targeted Site Visits (Safety Only)	Full Site Visits (Safety and Engineering)
Total Number of Distinct Properties	67	59
Visits by Boro.	60 Manhattan 7 Brooklyn	52 Manhattan 7 Brooklyn

Observation procedures included the following.

- A survey of the building site was conducted using a standardized *Location Report* form. Additional information, gleaned from interviews or observations not directly addressed by the Location Report format, was entered as comments.
- Interviews were conducted with construction staff and site safety personnel
- Photographic documentation of representative safety and quality conditions
- Relaying critical safety and/or construction conditions to the Department of Buildings

B.3 SUMMARY OF ADDITIONAL ASSESSMENTS AND OBSERVATIONS

Additional observations and assessments were made outside the scope of standard site observation procedures. These additional tasks gauged the accuracy of five selected concrete testing laboratories, assessed the quality of concrete laboratory testing and reporting at three facilities, and assessed the level of rebar fabrication and placement training offered by the Metallic Lathers and Reinforcing Ironworkers Union Local 46, during a visit to their Queens, New York training facility.

B.3.1 Comparative Concrete Testing

Concerns were raised regarding the concrete sampling and testing methods typically employed throughout the City. Specifically, the ability of testing labs to adequately perform both code compliant sampling methods, and produce accurate test results were assessed by the HRCO team during the fall of 2008.

Ten active concrete sites were randomly selected for additional observation. These selected sites ultimately encompassed five separate independent testing agencies. HRCO staff prepared cylinders and observed as personnel from the testing agencies made additional concrete test cylinders in the field, which HRCO staff delivered to an independent laboratory (the laboratories of The Port Authority of New York and New Jersey) for testing (see Appendix B.2).

Concrete strength test results from the laboratories of The Port Authority of New York and New Jersey were compared with the test results produced by the independent testing agencies. In general, the HRCO team found that the strength test results from the independent testing agencies compared favorably with the results from The Port Authority Laboratories.

B.3.2 Laboratory Quality Observations

The HRCO observed test procedures at selected testing facilities (Appendix B.3). These observations revealed significant variability in laboratory quality which warrants the Department’s continued monitoring of the laboratory’s ability to perform ASTM-compliant testing.

The Department has taken steps recently to raise the standards for concrete testing laboratories by requiring laboratories to be accredited under the American Association of Highway and Transportation Officials (AASHTO) Accreditation Program (AAP), the National Voluntary Laboratory Accreditation Program, or an equivalent accrediting agency. Previously approved concrete testing laboratories must achieve amended accreditation by July 1, 2010. In addition, the Department has also increased the knowledge base of inspectors regarding field testing requirements through enrollment in nationally recognized field testing certification programs.

B.3.3 Union Training Facility

HRCO Engineers visited the Training Facility of the Metallic Lathers and Reinforcing Ironworkers Union, Local 46 in Woodside, Queens on January 21, 2008. Discussions with union representatives highlighted both the practical and classroom training methods employed to promote proper rebar fabrication and placement best practices. HRCO staff observed the following:

- Extensive classroom facilities and availability of educational materials
- Practical, hands-on learning environments, including full-scale slab, beam and post-tensioning mockups.
- Practical hands-on fabrication instruction, including typical field-bending equipment.

According to the union representatives, field fabrication methods can provide quality and consistency levels commensurate with shop-bent reinforcing if proper bending techniques are utilized.

B.4 DOB PROCESS REVIEW

In conjunction with our observations of activities on a number of construction sites, the HRCO team had the opportunity to work with and observe Department of Buildings operations related to construction site safety. The HRCO worked directly with the Building Enforcement Safety Team (BEST), and reviewed their procedures for selecting sites for inspection and methods of conducting inspections.

The HRCO also reviewed DOB operations related to conducting technical reviews of plans and documenting incident and accident investigations.

These departmental assessments are reflected in the recommendations.

B.5 SUMMARY OF RECOMMENDATIONS

Recommendations fall into subcategories based on working areas of operation, including formwork design and construction, general site safety practices and procedures, special inspection practices and construction quality, worker fall hazards, and plan review. Within these five operational areas, recommendations may be classified as either direct, or those requiring further study. Further study recommendations may require additional investigation on the part of the DOB to fully gauge their applicability. Recommendations are summarized as follows.

B.5.1 Formwork

Formwork Design Requirements (HC-1)

Require essential specification information to be included on stamped formwork designs. Essential specifications shall include information required in chapter 6 of ACI 318. At a minimum, critical information such as reshoring sequences and schedules, required numbers of reshored floor levels, lumber material grade and rated stress, structural configuration and spacing of structural members, vertical formwork design, nailing schedules, and lateral bracing sequences and requirements shall be included.

Protection of Existing Construction (HC-2)

Require thresholds for the production of stamped and sealed formwork designs to include instances where adjoining structures are used directly or indirectly to support formwork.

Formwork Special Inspection (HC-3)

Require regular special inspection of formwork and reshore installations preferably by the formwork engineer of record, for structural integrity, conformance to essential specifications and the design intent.

Formwork Lateral and Wind Load Design (HC-4)

Clarify wind design requirements pertaining to formwork to incorporate oblique wind loads. Wind resistant design of formwork should conform with national standards for temporary construction, such as the American Society of Civil Engineers, Design Loads on Structures During Construction (ASCE 37).

Formwork Construction for Wind Resistance (HC-5)

Require perimeter formwork decking to be positively secured against uplift.

Wind Monitoring (Further Study, HC-6)

Require continual measurement of wind speed and direction during construction at prescribed elevations. Provide an audible early warning system to alert workers to possible wind danger.

Wind Tunnel Studies (Further Study, HC-7)

Conduct wind tunnel studies to observe and characterize wind behavior, and the resulting loads, along the perimeter of a completed concrete forming system. Further, conduct wind tunnel studies to observe and characterize wind behavior, and the resulting loads, throughout the field of a completed concrete forming system.

B.5.2 General Site Safety

DOB Inspector Qualifications (HC-8)

Enhance level of knowledge among DOB inspectors to include qualifications consistent with current NYC Building Code requirements regarding site safety practices, proper concrete formwork installation, and proper shoring and reshoring placement.

DOB Inspection Procedures (HC-9)

Update and publish standard sets of inspection protocols to create a consistent and uniform level of enforcement.

Housekeeping Requirements (HC-10)

Clarify specific housekeeping requirements in inspection protocols.

Site Safety Hierarchy (Further Study, HC-11)

Require site safety personnel's line of accountability to lead to owner (and not to the contractor or CM) to avoid a conflict of interest.

Upgrading Netting Requirements (Further Study, HC-12)

Study effectiveness of enhancing existing netting requirements

Material Handling (Further Study, HC-13)

Establish requirements for the use of outrigger systems for material handling.

B.5.3 Worker Falls

Fall Hazard Awareness (HC-14)

Implementation of a fall hazard awareness campaign through the use of posters, ads, and training at each jobsite for workers before they are allowed on site

Contractor Documentation (Further Study, HC-15)

Require contractor to document remedial actions taken when workers are identified as non-compliant regarding safety measures, including tie-off requirements. Remedial actions could include additional training sessions, suspension, or removal from job site.

Repeat Offense Enforcement (Further Study, HC-16)

Require a “two strikes and you’re out” provision to be levied against the contractor in the event the contractor fails to enforce safety regulations and procedures. This clause would require that the project is shut down a prescribed number of days after a predetermined number of code violations or reportable incidents. The purpose of the shut down is to provide the contractor a period of time to properly implement safety measures.

B.5.4 Special Inspections and Construction Quality

Special Inspection Rule (HC-17)

Strengthen outreach to industry on Special Inspection qualifications, and enforce the requirement that all Special Inspectors are properly registered and/or certified in compliance with NYC Special Inspection Rule requirements, effective July 1, 2009.

Field Inspection (HC-18)

Enhance level of knowledge among DOB inspectors to include qualifications consistent with the current NYC Building Code, specific to ACI Special Inspector training, to promote consistent enforcement of concrete practices, including field testing procedures.

Inspection of Testing Labs (HC-19)

Enhance level of knowledge among DOB personnel to include qualifications consistent with the current NYC Building Code, specific to ACI Special Inspector training, to promote consistent inspection of laboratory practices and conditions.

Reinforcing Bend Quality Assurance (HC-20)

Require documentation through photo and/or video that site bending practice complies with accepted industry standards and tolerances. Conformance may be spot checked by the DOB through inspection of logs and field conditions.

Reinforcing Placement Quality Assurance (HC-21)

Require documentation through photo and/or video that steel placement complies with accepted industry standards and tolerances. Conformance may be periodically spot checked by the DOB through inspection of construction logs and field conditions.

B.5.5 Plan Review

Monitoring of Peer Review (HC-22)

Retain professional engineers on behalf of DOB to monitor that peer reviews of identified projects are properly conducted as required by the NYC Building Code.

Structural Drawing Information (HC-23)

Require minimum level of information to be included on structural building drawings, including member end reactions and details with sufficient information to properly convey the design intent.

Monitoring of Structural Information Quality (HC-24)

DOB should retain professional structural engineers to review drawings to verify that the minimum level of structural information is contained on each set of structural drawings, shop drawings, and formwork drawings. Information to include requirements contained in ACI publications as noted in current NYC Building Code.

Monitoring Constructability (HC-25)

DOB should retain professional structural engineers to audit and verify that a sufficient, minimum level of details and detailing is included on each set of structural drawings and shop drawings. Minimum level of detailing to comply with requirements of ACI publications as noted in current NYC Building Code.

B.6 FORMWORK ISSUES

B.6.1 Description

The High Risk Construction Oversight (HRCO) High-Rise Concrete Team has observed numerous occurrences of inadequate design, construction, and inspection of formwork assemblies. In addition, due to the observed susceptibility of site-constructed dimension lumber (stick) formwork assemblies (Figure B.6.1) to wind and other lateral loads, the High-Rise Concrete Team concluded the current wind lateral load design criteria is not adequate. Based on HRCO team observations, formwork design in New York City typically considers only gravity loads and seldom, if ever, considers lateral loads due to wind loads or lateral loads due to accidental eccentricity of the gravity support system.

The High-rise Concrete Team, utilizing engineers under the supervision of a New York State Registered Professional Engineer, inspected 98 active HRCO sites. These sites included both union and non-union projects. Of the 98 site investigations, critical formwork deficiencies where construction or design deficiencies created imminently hazardous conditions, were found at fifty-seven percent (57%) of the sites. Observed formwork defects (Tables 1-2, Figures B.6.2-B.6.5) included both design and construction deficiencies. Deficient conditions include the following.

- Insufficient level of design information on the formwork drawings
- Construction not in conformance with the design intent
- Ineffective and insufficient inspection

Figure B.6.1: Typical Stick Formwork Assembly consisting of Timber Posts and Lumber Framing Elements

Table 1: Observed Formwork Defect Rates

	All Active Sites
Number of Fully Inspected Sites	98
Number of Observed Formwork Construction and Design Defects Deemed *Critical*	56 (57%)

Table 2: Typical Critical Formwork Defects

No Stamped Formwork design (as required by NYC Building Code)
Formwork construction not in conformance with design
Premature stripping or premature reshore removal (as required by design)
Insufficient number of reshored floors (as required by design)
Insufficient number of shored floors (as required by design)
Insufficient number or improperly installed lateral braces (as required by design)
Insufficient post spacing (as required by design)
Insufficient design data regarding sequencing of form removal or adequate concrete strength
Premature removal of lateral bracing (as required by design)

.

Figure B.6.2: Formwork Construction Not in Conformance with Design, Unstable Timber Posts used as Filler between Steel Shoring Tower and Concrete Soffit

Figure B.6.3: Improved Filler Material Installation (Laid Horizontally) between Steel Shoring Tower and Concrete Soffit

Figure B.6.4: Formwork Construction not in Conformance with Design, Damaged Timber Post

Figure B.6.5: Insufficient Post Spacing, Missing Posts at Stringer Element (Top Center)

B.6.2 Recommendation HC-1: Design Requirements

Require essential specification information to be included on stamped formwork designs. Essential specifications shall include information required in chapter 6 of ACI 318. At a minimum, critical information such as reshoring sequences and schedules, required numbers of reshored floor levels, lumber material grade and rated stress, structural configuration and spacing of structural members, vertical formwork design, nailing schedules, and lateral bracing sequences and requirements shall be included.

Critical design defects (Table 3), such as the failure to properly prescribe the number of reshored floor levels required to support formwork assemblies, place critical engineering decisions that affect the performance of the structure in the hands of unqualified persons at the site. Contractors often lack the requisite experience and knowledge necessary to judge the adequacy of an engineering design, and can only assume a properly stamped & sealed formwork design drawing contains sufficient design information.

Table 3: Critical Formwork Defect Origin

Number of Fully Inspected Site Observations	98
Number of Critical Formwork Defects	56 (57%)
Number of Critical Formwork Defects Attributable to Design	25 of 56 (45%)

B.6.3 Recommendation HC-2: Protection of Existing Construction

Require thresholds for the production of stamped and sealed formwork designs to include instances where adjoining structures are used directly or indirectly to support formwork.

Currently, formwork assemblies in excess of fourteen feet, constructed of two-stage shores, supporting power buggies, or supporting loads in excess of 150 psf require stamped and sealed formwork design drawings[5]. Recent incidents however, have highlighted a failure of the industry to properly address the effect of concrete pressures on adjacent structures (Figure B.6.6). While the HRCO recognizes the Engineer of Record is ultimately responsible for the stability and integrity of any adjacent walls exposed during construction or demolition, clear requirements addressing concrete placement are needed.

Current building code requirements read in part: *When any construction or demolition operation exposes or breaches an adjoining wall…the person causing the construction shall, at his own expense perform the following:*

> *1. Maintain the structural integrity of such walls, have a registered design professional investigate the stability and condition of the wall, and take all necessary steps to protect such wall.* [6]

[5] See BC 1906.3 Design of Concrete Formwork

[6] See BC 3309.8 Adjoining Walls

Figure B.6.6: Wall Failure Attributed to Concrete Pressures Imparted by Adjacent Construction

B.6.4 Recommendation HC-3: Formwork Inspection

Require regular special inspection of formwork and reshore installations preferably by the formwork engineer of record, for structural integrity, conformance to essential specifications and the design intent.

Currently, formwork assemblies are self-inspected by the contractor installing the formwork; clearly presenting a critical conflict of interest. Construction defects (Table 4) account for more than seventy-five percent (75%) of observed formwork deficiencies (Figures B.6.8-B.6.11), and improper construction practices such as premature removal of formwork, or failure to install large portions of specified lateral bracing elements, present a critical hazard to worker and public safety.

Table 4: Critical Formwork Defect Origin

Number of Fully Inspected Site Observations	98
Number of Critical Formwork Defects	56 (57%)
Number of Critical Formwork Defects Attributable to Construction	44 of 56 (79%)

Figure B.6.7: Construction Loads can be Significant[7]. Verification of Proper Formwork Assembly is Critical

[7] Configuration Shown Likely to Exceed 150 Pounds per Square Foot

Figure B.6.8: Unstable[8] Stacked Truss-Type Stringer Assembly, Not in Conformance with Design

[8] Prone to failure through twisting (Lateral Torsional Buckling) of wood truss elements

Figure B.6.9: Stacked Engineered Lumber Formwork Failure in Queens Attributed to a Lack of Lateral Bracing.

Figure B.6.10: Lack of Adequate Support under Post Base (Center), Not in Conformance with Design.

Figure B.6.11: Improper Lateral Bracing Installation, Not in Conformance with Design. Lateral Braces are not Secured to Slab, Unable to Resist Load Reversals

Existing contractor-managed inspection procedures have failed to ensure proper conformance to design specifications. These inspections require oversight by a qualified individual. Inspection requirements should include the following:

- Inspection of initial formwork installation for general conformance with the design to establish contractor familiarity with proper installation practices and procedures.
- Inspection of subsequent similar formwork installations for general conformance on a regular basis
- Inspection of critical formwork elements such as multi-tier tower assemblies and outriggers for general conformance commensurate with floor cycle times.
- Inspection of formwork installations with irregular configurations for general conformance to establish contractor familiarity with proper installation practices and procedures.
- Inspection of subsequent similar irregular formwork installations for general conformance on a regular basis

As an example, as recently as March 12th, 2009, a vertical formwork failure occurred at 450 W. 14th Street, presenting a significant falling concrete and debris hazard to those below. Initial reports indicate the contractor-inspected vertical formwork configurations were not in conformance with the formwork design. Appropriate numbers of form ties were not installed (Figure B.6.12), leading to a blow-out failure and concrete spillage (Figure B.6.14). Supplemental inspection by a special formwork inspector or the formwork designer would have likely identified this insufficiently-constructed installation.

Subsequent protective action by the Department of Buildings included a mandatory re-inspection by the formwork designer prior to resuming work, and required production of signed and sealed written procedures for future placements.

Figure B.6.12: Vertical Formwork Configuration, Missing Walers Specified by Formwork Designer

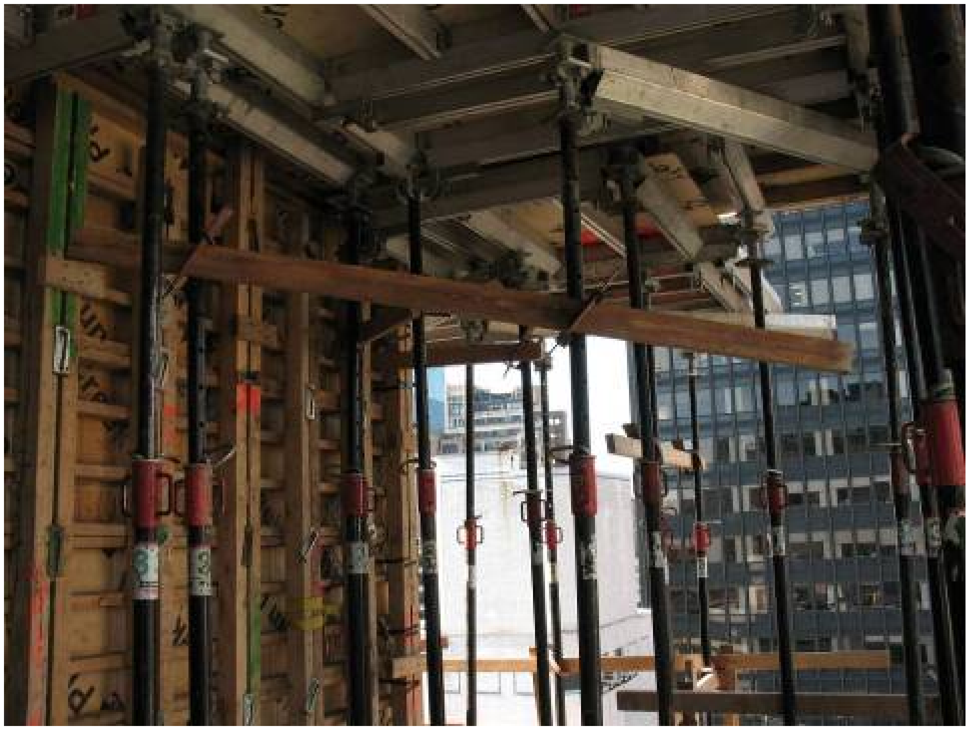

Figure B.6.13: Typical Proper Waler Installation (Wall, Left)

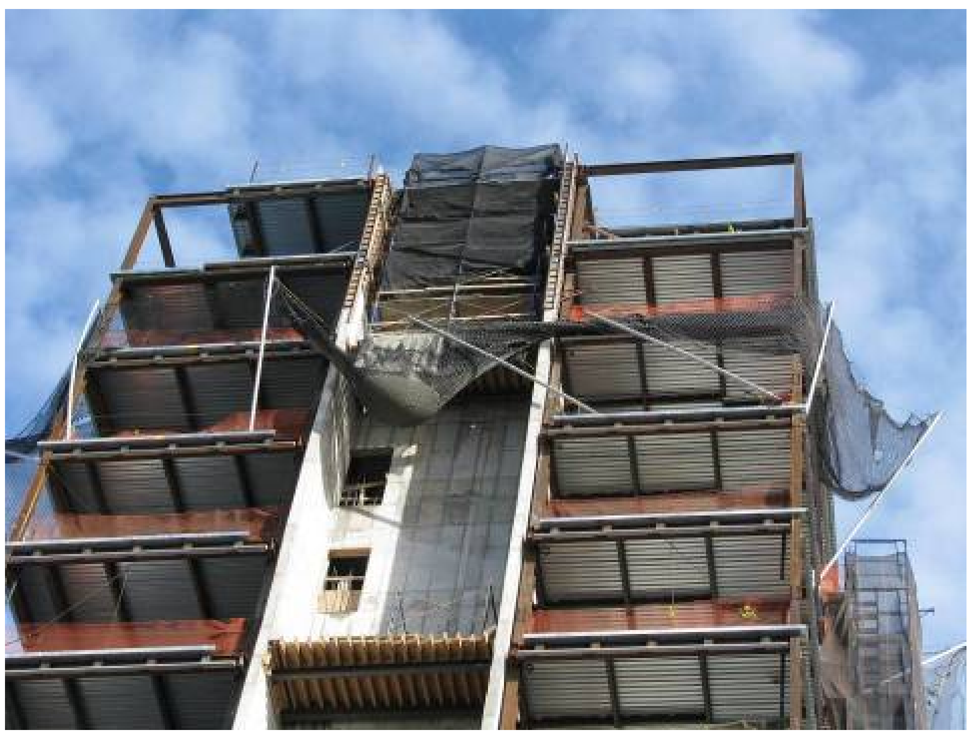

Figure B.6.14: Spilled Concrete after Form Blow-out Restrained by Horizontal Netting (Center)

Table 5 provides a comparison of formwork design, construction and inspection requirements from both the 1968 and 2008 NYC Building Codes. Figure B.6.15 provides direct citations for inspection requirements.

The provisions in the two codes are very similar with the exception of the inspection requirements. The 1968 Code requires inspection for geometric accuracy of the formwork by an architect or engineer. It also requires a check to verify that the in place formwork conforms to the drawings. Furthermore, the 1968 code requires periodic inspections to detect incipient problems. This check may be done by the person supervising the work.

The 2008 Code requires that a *qualified person* inspect for geometric accuracy.

The 1968 provision of checking conformance to the drawings and periodic inspections for “incipient problems” is an important aspect of assuring the structural integrity of the formwork (though it would be better if the Registered Design Professional for the formwork were also required to conduct this inspection rather than the superintendent).

Table 5: Comparison of Formwork Provisions in the NYC 1968 and 2008 Building Code.

	1968 (October 1, 2004 Update)	2008
Design	Safely support all vertical and lateral loads Designed by Registered Design Professional for (among other things) heights exceeding 14 ft or total load exceeding 150 PSF. Minimum lateral load (from wind or otherwise) = greater of 100 plf (lb/ft) along the edge of the formwork or 2 percent of the total dead load of the floor. Lateral loads include wind. Special loads include uplift.	Safely support all vertical and lateral loads Designed by Registered Design Professional for (among other things) height exceeding 14 ft or total load exceeding 150 PSF. Minimum lateral load (from wind or otherwise) = greater of 100 plf (lb/ft) along the edge of the formwork or 2 percent of the total dead load of the floor. Lateral loads include wind. Special loads include uplift.
Construction	Shall be constructed in conformance with design drawings (where such design required). Specific plumb and alignment requirement for multi-floor forms.	Shall be constructed in conformance with design drawings (where such design required). Specific plumb and alignment requirement for multi-floor forms.
Inspection	Shall be inspected by the engineer or architect to verify sizes of the members being formed. …forms shall be inspected for conformance with the form design drawings, when such drawings are required… Such inspections may be made by the person superintending the work periodically during the placement of concrete to detect incipient problems. A record of inspections shall be kept on site.	Shall be inspected prior to placement of reinforcing steel to verify that the sizes of the concrete members that are being formed conform to the construction documents and form design drawings. Such inspections shall be conducted by a qualified person designated by the contractor. During and after concreting, the elevations, camber and vertical alignment of concrete shall be inspected… A record of inspections shall be kept on site.

2008 NEW YORK CITY BUILDING CODE

1906.2 Inspection. Formwork, including shores, reshores, braces and other supports, shall be inspected prior to placement of reinforcing steel to verify that the sizes of the concrete members that are being formed conform to the construction documents and form design drawings. Such inspections shall be performed by a qualified person designated by the contractor. Subsequently, inspections shall be performed by such person periodically during the placement of concrete. During and after concreting, the elevations, camber, and vertical alignment of formwork systems shall be inspected using tell-tale devices. A record of all such inspections shall be kept at the site available to the commissioner. The names of the persons responsible for such inspections and the foreman in charge of the formwork shall be posted in the field office.

1968 NYC Building Code

(1) Formwork, including shores, reshores, braces, and other supports, shall be inspected by an engineer or architect to verify the sizes of the concrete members being formed, as provided in article five of subchapter ten of this chapter. In addition, such forms shall be inspected for conformance with the form design drawings, when such drawings are required by the provisions of subdivision (c) of this section; and/or conformance with the provisions of this section. Such inspections may be made by the person superintending the work. Both such inspections shall be made prior to placement of reinforcing steel. Subsequently, inspections shall be made by the person superintending the work periodically during the placement of concrete to detect incipient problems.
(2) During and after concreting, the elevations, camber, and vertical alignment of formwork systems shall be checked using tell-tale devices.
(3) A record of all such inspections shall be kept at the site available to the commissioner, and the names of the persons doing the inspecting and the name of the foreman in charge of formwork shall be posted in the field office.

Figure B.6.15: Code Requirements

B.6.5 Recommendation HC-4: Lateral and Wind Load Design

Clarify wind design requirements pertaining to formwork to incorporate oblique wind loads. Wind resistant design of formwork should conform with national standards for temporary construction, such as the American Society of Civil Engineers, Design Loads on Structures During Construction (ASCE 37).

As observed by High-rise concrete inspection teams, formwork is typically not securely anchored in place and has no inherent ability to resist the effects of wind loads. As a result, during the period of time between formwork erection and concrete placement, formwork that is subject to wind loads is susceptible to collapse or displacement. Although the occurrence of significant wind storms is rare and there is limited historical documentation of wind-related formwork failures (Table 6), when wind related formwork failures have occurred, these events have caused life threatening damage (Figures B.6.16-B.6.17).

Modified design criteria may also include considerations for exposure conditions as, historically, wind events are prevalent at western water exposures (Figure B.6.18).

The ASCE 37 standard prescribes applicable loads to be considered during the design of temporary structures such as formwork. The standard considers the temporary nature and short load duration when establishing the magnitude of load to be used in design. Lateral loads included in ASCE 37 that apply to formwork design are horizontal construction loads and wind loads. Relative to wind load criteria on temporary structures, ASCE 37 references ASCE 7, *Minimum Design Loads for Buildings and Other Structures* as the basis.

Figure B.6.16: Formwork Failure at Hudson River Exposure

Figure B.6.17: Formwork Failure in Reported 30-40 mph Winds

Table 6: Historic NYC Formwork Wind Events

Address	Boro.	Incident Date	Description
100 Jay Street	Brooklyn	7/24/2006	Wind dislodged several formwork deck panels from 27th floor.
246 Spring St.	Manhattan	12/23/2007	Wind dislodged shoring element from the 39th Floor
469 West St.	Manhattan	3/9/2008	Wind dislodged formwork from the 15th floor
808 Columbus	Manhattan	6/11/2008	Wind dislodged formwork in reported winds of 30-40 mph
314 11th Ave	Manhattan	10/22/2008	Wind dislodged (2) 3x4 timber posts from 16th floor. Leading Edge deck lifted, removed voluntarily by contractor

Figure B.6.18: Historic Formwork Failures due to Wind Events

Loading criteria for formwork has been reviewed by cross-reference of applicable enforceable codes. The following compares the criteria and differences between the various codes.

Codes reviewed for this study were OSHA 1926.703, OSHA Subpart L, ANSI A10.9-2004, NYC 1968 Building Code and 2008 Building Code, ASCE 7-02 *Minimum Design Loads for Buildings and Other Structures*, ASCE 37-02 *Design Loads on Structures During Construction*, and ACI 347-04 *Guide to Formwork for Concrete*.

The ANSI A10.9-2004 was found to be the most commonly referenced standard. Both the 1968 and 2008 NYC codes reference this ANSI standard. Also, both codes contain design criteria similar to design criteria contained in this ANSI standard.

Lateral loading found in ANSI 10.9, Section 7.2.1, is defined as the following.

- The greater of 100 plf along the form edge

- 2% of the total dead load on the floor distributed along the slab edge

Wind requirements of ASCE 7 include a minimum criteria of 15 psf and reduced wind speeds reflecting reduced probability of storm events for temporary construction. By comparison the NYC Building Code has similar criteria regarding 100 plf at the form edge and 2% of the dead load. The lateral wind load and uplift is addressed as a specific wind pressure within the NYC code RS9-5.

Uplift is addressed within ASCE 7-02, and is included in Chapter 6 as the upward load on the underside of overhangs and canopies. ASCE 7-02 also provides basic wind speed data for coastal areas, prone to hurricane activity, such as New York City.

ASCE 37-02 *Design Loads on Structures during Construction* lists factors that reduce the basic wind speed found in ASCE 7-02 according to an assumed construction period that is less than 5-years. According to ASCE 37, the construction period shall be taken as the time interval from first erection to structural completion of each independent structural system.

Based on an estimated construction period, a factor is given in ASCE 37. That factor reduces the basic wind speed found in ASCE 7 such that the reduced design wind velocity would have the same probability of being exceeded during the construction period as the 50-year mean recurrence interval design wind has during a 50-year period.

B.6.6 Recommendation HC-5: Formwork Construction for Wind Resistance

Require perimeter formwork decking to be positively secured against uplift.

Historically, DOB incident data indicates formwork failures have involved leading edge elements, such as unsecured plywood sheeting that was lifted by the wind along building perimeters. Although some formwork designers provide nailing schedules for decking elements, many designs improperly rely on the self-weight of the assembly alone to resist overturning and liftoff. Requirements for positive connection between decking and rib elements are needed to increase structural integrity of perimeter elements. Although modular engineered formwork systems (Figure B.6.19) require nailed connections between decking and rib elements in the same manner as “stick” assemblies, such systems also provide the added benefit of automatic, positive connection between towers, stringers, and ribs. Usage of such modular systems is commonplace (Table 7).

Table 7: Formwork Type Usage

Respondent City	Percentage of Jobs with Modular Engineered Formwork	Average Floor Cycle on Jobs with Modular Engineered Formwork (days)	Percentage of Jobs with Stick Forms	Average Floor Cycle on Jobs with Stick Forms (days)
Chicago, IL	80	3-4	20	3-4
Fairfax County, VA	10	7	90	7
Charlotte, NC	98	NA	2	NA
Pompano Beach, FL	25	3	75	5
San Francisco, CA	85	5	15	5
San Jose, CA	85	5	15	7
Toronto, Canada	80	5	20	NA

Figure B.6.19: Modular Engineered Formwork System

B.6.7 Recommendation HC-6: Wind Monitoring (Further Study)

Require continual measurement of wind speed and direction during construction at prescribed elevations. Provide an audible early warning system to alert workers to possible wind danger.

Wind velocity and direction are highly sensitive to site-specific characteristics such as terrain, exposure, and surrounding structures. Thus, measurements of wind speed at remote locations[9] are not reliable surrogates for all localities when construction safety is in question. Site-specific wind readings will provide Site Safety Managers with the data necessary to mitigate wind-induced hazards. In addition, the Department of Buildings may use this additional site-specific wind data to refine wind-related code requirements.

Wind monitoring technology is established, and has been utilized most notably at 200 Murray Street, a high-rise construction site[10] which incorporated ultrasonic anemometers and remote data loggers.

B.6.8 Recommendation HC-7: Wind Tunnel Studies (Further Study)

Conduct wind tunnel studies to observe and characterize wind behavior, and the resulting loads, along the perimeter of a completed concrete forming system. Further, conduct wind tunnel studies to observe and characterize wind behavior, and the resulting loads, throughout the field of a completed concrete forming system.

A review of current literature indicates little guidance exists regarding the behavior and resulting loads that are caused by wind on the leading edges of a concrete forming system at the perimeter of a building. Likewise, little was found as a guide regarding wind loads throughout the field of a completed concrete forming system.

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[9] NYC wind speeds are commonly measured at LaGuardia Airport, Newark Airport, and Central Park

[10] The Goldman Sachs Building, supervised by Tishman

B.6.9 Additional HRCO Data

Table 8: Sites with Critical Formwork Defects

Site No.	Boro	Notes
3	B3[11]	Concrete specifications limit stripping time to minimum of 48 hours under best conditions with Type III Cement. Stripping occurring at 24 hours.
4	B1[12]	Formwork design called for 9 floors of reshores, only 2 currently reshored.
4	B1	Incomplete formwork design. Bracing removed day of pour. Reshores prematurely removed in areas.
5	B1	General contractor stated he used a "rule of thumb" to determine the amount of reshores needed, number of floors to reshore, and when to remove re-shores.
11	B1	No reshore drawings.
13	B1	No stamped formwork design. Working off set marked "Preliminary, Not for Construction"
14	B1	Forms stripped prior to knowledge of concrete strength as noted in project specs.
15	B1	Per Contractor, no form inspections performed. Formwork post spacing not in conformance. No formwork sequence provided. No knowledge of concrete strength prior to stripping.
15	B1	Incomplete formwork design (missing details for thicker 22" slab).
16	B1	Form bracing not installed per drawings. No form stripping sequence available.
19	B3	Formwork installation not in conformance with design documents. No

[11] Borough of Brooklyn

[12] Borough of Manhattan

		design for cantilevered work platform. No stripping sequence available.
20	B1	Formwork bracing not in conformance with design. Improper shoring posts (#3 instead of #4).
21	B1	Formwork drawing for 19th floor not available.
23	B3	Formwork stripping sequences not available. No contractor knowledge of concrete strengths at time of stripping. Reshores removed prior to verification of required strength.
23	B3	Reshoring of balconies not in conformance with drawings.
29	B3	Form bracing not installed in conformance with design.
29	B3	Bracing removed during concrete placement.
29	B3	No reshore sequence design provided.
33	B3	Missing shoring towers. Improper placement of shoring towers.
34	B1	Sequence and timing of formwork cracking not provided in formwork design.
36	B1	Insufficient number of reshored floors. No formwork stripping sequence available.
37	B1	No reshoring design provided. Reshores not in conformance with minimum spacing requirements. Unknown number of required reshored floors.
40	B1	Improper formwork tie-down installation.
41	B1	Formwork design not stamped by PE.
43	B1	Timing of formwork stripping in direct violation of specification.
44	B1	Formwork drawing is for second floor, but was used throughout construction.
45	B1	Improper formwork installations.
46	B1	Formwork installation not in conformance with design documents.
47	B1	No knowledge of concrete strength prior to stripping. Improper edge post

		installation.
48	B1	Missing formwork bracing per drawings.
49	B1	Incomplete reshoring design (no reshoring sequence). Missing bracing detail.
50	B1	Lateral brace removal during pour. No knowledge of concrete strength prior to stripping.
55	B3	Bracing removed in violation of general notes. Insufficient numbers of reshored floors.
55	B3	Insufficient numbers of lateral braces installed below forming floor. Most braces not secured to deck. Reshoring and stripping of formwork not per designer's general notes. Memo issued by designer implies general notes are "suggestions".
55	B3	No reshore sequence provided. No formwork design drawings for multi-level formwork.
56	B1	Lack of reshore spacing specifications. Reshores clustered in areas to allow localized work in "shore-free" areas.
56	B1	No reshore design provided.
57	B1	Lack of formwork drawings. Using adjacent building's formwork design. No vertical formwork specifications. No approved formwork drawings.
57	B1	No reshore sequence provided.
58	B1	No reshore sequence provided.
58	B1	Missing number of shoring towers.
62	B1	Wall forms removed prior to knowledge of concrete strength.
69	B1	No stamped formwork drawings.
72	B1	Improper shore post spacing. No reshore specification.
73	B1	No formwork drawings available.

84	B3	No reshore sequence available, based on contractors experience only.
85	B3	Improper tower installation (unstable timber posts)
87	B1	Timber on ends of towers. Formwork workmanship unstable. Missing reshoring sequence. Lateral shore bracing not in conformance with design.
87	B1	Premature form stripping.
87	B1	Premature lateral bracing removal. No knowledge of concrete strength prior to stripping.
88	B1	Observed removal of PERI system lateral braces immediately below active casting floor. Design calls for reshoring at 14 days. Unused lateral braces.
88	B1	PERI tower height exceeds design.
90	B1	Premature formwork removal in violation of specifications. No reshore sequence
91	B1	No cracking specification.
91	B1	No stripping sequences available. Sequencing not specified in design.
92	B1	Improper post tie-offs at edge.

B.7 SITE SAFETY

B.7.1 Description

The High Risk Construction Oversight (HRCO) High-Rise Concrete Team documented numerous instances of unsafe jobsite conditions and developed recommendations to mitigate these hazards. Unprotected edges (fall hazards) were observed to have the greatest potential to endanger the safety of the public as well as that of construction workers themselves (Figures B.7.1-B.7.3). Other aspects of construction such as non-code compliant storage of material throughout the construction site, especially on stripping floors, provide unsafe conditions relative to egress and sources of wind-blown debris. The hazard of falling debris is ever present in New York City. Between January 2006 and June 2008, DOB records list over 200 falling material incidents, most from floors with active stripping operations. Seven significant debris incidents presenting a hazard to the public occurred during the month of March 2009 alone, and were primarily formwork related.

For example, plywood formwork debris fell from the 29th floor in June 2006, striking and injuring a female pedestrian, requiring medical attention. In February 2009, a piece of 3x4 formwork debris fell from the upper floors of a construction site on West 45th Street, Manhattan, injuring a flagman.

Figure B.7.1: Debris Accumulation Presenting a Public and Worker safety Hazard. Note Unprotected and Unsecured Building Edge (Background).

Figure B.7.2: Unacceptable Debris Accumulation and Material Storage during Formwork Operations. Lack of Storage Space Concentrates Material within Work Areas, Impeding Egress Pathways. Note Shoring Post (Center) Stopped Short of Floor over Stacked Material.

Figure B.7.3: Stacked and Unsecured Material Presents a Wind Borne Debris Hazard When Placed Near Building Edges

Additionally, recommendations regarding New York City's construction inspectors will help establish more consistent DOB inspection procedures and enforcement. As industry complaints regarding inconsistent levels of enforcement are common, recommendations relative to the standardized application of violation thresholds and new low-risk construction practices provide a basis for long term violation reductions.

B.7.2 Recommendation HC-8: DOB Inspector Qualifications

Enhance level of knowledge among DOB inspectors to include qualifications consistent with current NYC Building Code requirements regarding site safety practices, proper concrete formwork installation, and proper shoring and reshoring placement.

Inspectors should be required to receive training equivalent to that of safety professionals in the private sector, such as a Certified Safety Professional, NYC Certified Site Safety Manager, Occupational Health and Safety Technologist, or the

Construction Health and Safety Technologist, either through DOB-provided education or through external channels[13].

Increasing the inspector's knowledge base in this manner is critical to maintaining the DOB's credibility within the construction community, allowing them to enforce code requirements with continued authority and consistency. In addition to basic safety practice education, DOB inspectors should be trained to do the following:

- Read and understand formwork design drawings
- Become ACI Level 1 Certified[14]
- Understand the importance of proper shoring sequences and practices
- Quickly Identify and Address Risky Construction Operations

B.7.3 Recommendation HC-9: DOB Inspection Procedures

Update and publish standard sets of inspection protocols to create a consistent and uniform level of enforcement.

A repeated industry criticism of DOB inspection practices is the non-uniform level of enforcement. Updated protocols are to include specific inspection check lists listing thresholds for violations, as well as thresholds for Stop Work Orders.

Current DOB inspection checklists and standard operating procedures (SOP), while specific in reference to many code requirements, do not provide guidelines sufficient to provide for a uniform enforcement of safety-critical requirements. For example, inspectors are currently not uniformly equipped to judge the acceptability of common unsafe conditions (Figs. B.7.4-B.7.7). Rather, they rely primarily on their own varying level of training, experience, and degree of tolerance of non-conforming issues.

[13] BCSP Board of Certified Safety Professionals, 208 Burwash Avenue, Savoy, IL 61874.

[14] The DOB has already begun to certify inspection staff per ACI Level 1

Figure B.7.4: Localized Gap Condition at Guardrail. Lack of Specificity Regarding Allowable Gap Distance (if any) Forces Inspector to Make a Potentially Inconsistent Judgment Call

Figure B.7.5: Localized Discontinuous Guardrail Condition at Material Storage Location. Lack of Specificity Regarding Allowable Gap Distances Forces Inspector to Make a Potentially Inconsistent Judgment Call

Figure B.7.6: Building Exposure with Incomplete Edge Protection. Code Provisions Do Not Address Violation Thresholds Relating to Percentage of Exposure without Protection

Figure B.7.7: Localized Variation in Guardrail Height. Code Provisions Do Not Address Allowable Height Tolerances (if any). Lack of Specificity Forces Inspector to Make a Potentially Inconsistent Judgment Call

An upgraded SOP would benefit greatly from an array of easily-recognizable photographic examples. Explicit SOP inspection protocols and thresholds for violations will eliminate the need for DOB inspectors to exercise personal judgment regarding violations. This revised SOP protocol may include the following model requirements, augmenting and clarifying existing protocol guidelines (Figure B.7.8).

- Maintain less than 6” between discontinuous guardrails and building elements, or between collections of stored material and the resumption of guardrail protection. *Enforcement level: Violation*

- Deflection of guardrail cables shall not exceed ¼” for every foot of unsupported length (tautness)[15]. *Enforcement Level: Violation*

- Without Exception, fully compliant guardrails shall be continuously installed throughout building perimeter. *Enforcement Level: Stop Work Order*

16. Guardrails and Toeboards

a. Standard guardrail shall consist of a 2x4 top rail at 36 to 42 inches above the floor or platform, a 1x4 intermediate rail between the top rail and floor and both shall be supported by 2x4 wood posts not more than 8 ft apart. (§27-1050(a)(1)).
NOTE: Top edge of guardrail height shall be 42" plus or minus 3" (OSHA §1926.502(b)(1)

b. Alternate Metal Guardrail shall consist of at least 1 ¼ in diameter standard pipe or 2x2x1/4" angles. Same spacing as above. (§27-1050(a)(2))

c. At removable sections of railing, substantial chains or rope shall be taut at the same height as standard guardrails. (§27-1050(a)(3))

d. Guardrails shall be designed to supported without failure a 200 lb concentrate outward or downward force anywhere along the length of the rail. (OSHA §1926.502(b)(3))

e. Guardrails shall not deflect lower than 39 inches above the floor under 200 lb concentrated load. (OSHA §1926.502(b)(4))

f. Cable used as a guard rail shall be a minimum of 3/8" diameter mild plow steel with flagging at a maximum of 6 ft spacing to increase visibility. A positive tensioning system such a turnbuckle shall be provided when a cable is used. (OSHA §1926.502(b)(9))

If no guardrail is present, issue the following Hazardous ECB violation and issue a full stop work order:

B46	27-1009a	Y	No guardrails/midrails provided	Provide adequate guardrail/midrail

If items listed in Section 16a thru 16f are not met, issue the following Hazardous ECB violation for each item not met and depending upon the observed conditions issue a full or partial stop work order if warranted:

B5U	27-1050	Y	Inadequate guardrails/midrails provided	Provide adequate guardrail/midrail

Figure B.7.8: Portion of Current DOB Standard Operation Procedure v6

[15] Compare to DOB SOP v6 Section 16 (c), (f)

B.7.4 Recommendation HC-10: Housekeeping Requirements

Clarify specific housekeeping requirements in inspection protocols[16].

Similar to the need to clarify enforcement of guardrail conditions, and in an attempt to reduce the risk of falling debris, a uniform understanding of acceptable housekeeping conditions is required. An upgraded SOP would benefit greatly from an array of easily-recognizable photographic examples (Figures B.7.9-B.7.11).

Figure B.7.9: Unacceptable Level of Debris Accumulation. *Enforcement Level: Violation*

[16] Housekeeping provisions to augment OSHA 29 CFR 1926.25

Figure B.7.10: Unacceptable Level of Debris Accumulation Presenting a Major Impediment to Egress. ***Enforcement Level: Stop Work Order***

Figure B.7.11: Acceptable Level of Debris Accumulation

B.7.5 Recommendation HC-11: Site Safety Hierarchy (Further Study)

Require site safety personnel's line of accountability to lead to owner (and not to the contractor or CM) to avoid a conflict of interest.

A precedent for this recommendation is Los Angeles where Site Safety managers are hired directly by the owner. Observations and interviews collected during 181 site visits indicate a Site Safety Manager's ability to maintain appropriate levels of safety on job sites is directly related to the owner's and contractor's willingness to support his efforts. A May, 2004 study[17] found that the Site Safety Personnel's authority level is highly correlated with overall safety. Additionally, current American Society of Civil Engineers (ASCE) policy[18] states that "Owners should take an active role in project safety." Enabling safety personnel to pursue their duties unencumbered by conflicts of interest is an efficient way to achieve increased levels of safety.

Site Safety Managers have a purpose, but are currently ineffectual. Even highly-qualified and knowledgeable safety managers were observed to be ineffective, relative to enacting and enforcing safety compliance, without the contractor's direct support. Because contractors are under significant pressure to adhere to strict construction schedules, they are generally not inclined to delay projects to enforce safety regulations (Figure B.7.12) throughout the construction site. Although cooperation was observed to exist between the General Contractor and Safety Personnel at a number of sites, HRCO team members noted this as the exception rather than the rule.

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[17] *Benchmark Studies on Construction Safety Management in China.* Journal of Construction Engineering and Management

[18] ASCE Policy Statement #350 (1998)

Figure B.7.12: Failure to Tie-off within 10 feet of Unprotected Edge

HRCO field note entry of significance regarding excellent safety coordination:

- 1-Oct. 2008, Site No. 23: Owner-hired Site Safety Manager, observed good safety response over contractor hired Site Safety Manager
- 2-Oct. 2008, Site No. 40: Interview with Site Safety personnel indicate preference is to be hired by owner, and owner involvement improves ability to enforce safety regulations.
- 22-Oct. 2008, Site No. 48: Site safety manager observed that they are more successful on project when they are retained by the owner.

HRCO field note entries of significance regarding poor safety coordination:

- 18-Aug. 2008, Site No. 85: Poor chain of command between Site Safety Manager and trades. Lack of respect between trades and safety manager. Site Safety Manager unable to control project, under pressure to keep low profile.

- 27-Aug. 2008, Site No. 90: Limited ability of SSM to maintain control of site. Housekeeping violations and unprotected edge violations previously issued by BEST.
- 24-Sept 2008, Site No. 55: Additional concrete contractor safety personnel onsite, but ineffective.
- 25 Sept. 2008, Site No. 57: Site Safety personnel not effective in maintaining safety. Insufficient perimeter protection. Unprotected edges throughout site. Poor housekeeping
- 21-Oct. 2008, Site No. 56: General contractor slow to address safety issues. Lack of fall protection between buildings. Fall hazards at ladders to stripping floor (Safety violations issued following week following deteriorating conditions).
- 23-Oct. 2008, Site No. 85: Site Safety Manager ineffective. Unprotected edges throughout. Most workers not tied off. No safety coordination or enforcement within project team.
- 5-Nov. 2008, Site No. 85: Site Safety Personnel have no control over site safety. Still inadequate edge protection. No tie off compliance. Blocked egress. Project team is not making safety a priority.

B.7.6 Recommendation HC-12: Upgrading Netting Requirements (Further Study)

Study the effectiveness of enhancing existing netting requirements[19].

Current NYC construction industry practice regarding formwork construction relies heavily upon the use of site constructed dimension lumber (stick) assemblies (Figure B.7.13), consisting of timber posts and lumber framing members which typically create large volumes of waste and debris. In recognition of the likelihood that this debris represents a potential hazard, and the further recognition of the potentially serious hazards created if the debris is blown or falls from a building, a number of general contractors have independently elected to utilize full-height vertical netting (Figure B.7.14) to better contain flying debris, in excess of current DOB code requirements.

[19] Netting Provisions to augment OSHA 29 CFR 1926.502 and 1926.750

As the industry begins to independently move in the direction of more stringent netting requirements, and while public safety remains a high priority, a review of current standards is necessary.

Figure B.7.13: Typical Site Constructed Dimensional Formwork Assembly (Stick Form Construction)

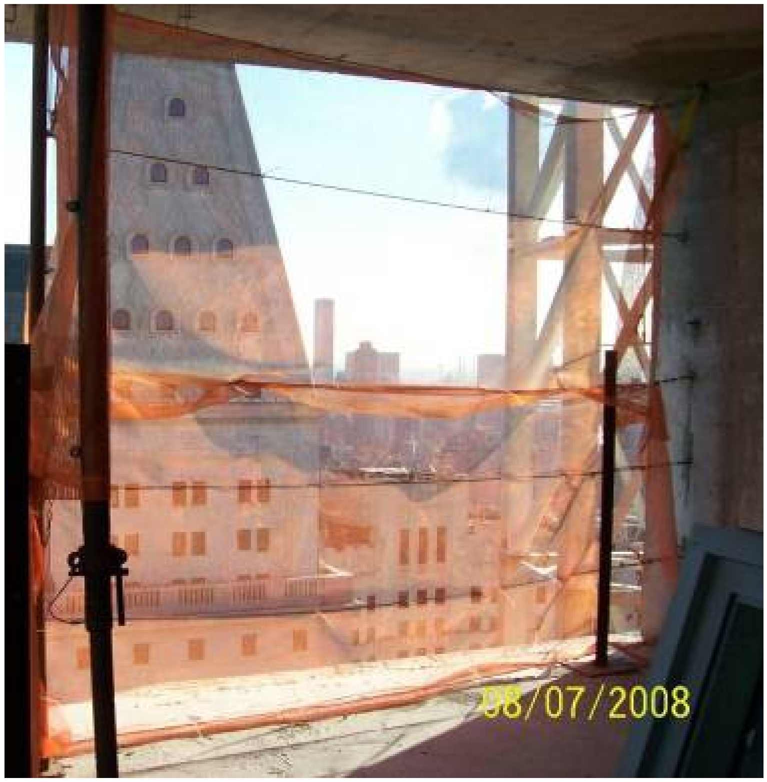

Figure B.7.14: Full-height Vertical Netting Provides Additional Barrier to Flying Debris

Further study of cocoon construction practices (Figure B.7.15), which can contain debris more effectively than full-height netting alone, is also warranted. When correctly implemented, cocoon configurations provide protection against worker fall incidents by allowing construction to proceed within an enclosed temporary structure encircling the building footprint. Consideration must be given however, to the cocoon system's effect on fire safety, wind design and egress.

Figure B.7.15: Cocoon Construction in Operation.

B.7.7 Recommendation HC-13: Material Handling (Further Study)

Establish requirements for the use of outrigger systems for material handling.

Outrigger platforms are temporary structures cantilevered off building edges (Figures B.7.16-B.7.17) that can be constructed to provide a continuously-protected material rigging area outside the building footprint. Incorporation of outrigger platforms into the construction scheme will eliminate the need to interrupt otherwise continuous edge protection, allowing rigging and flying operations to proceed in a protected environment[20]. Additionally, outrigger systems, located and installed at specific locations on each floor, will eliminate subjecting crane booms to lateral loads when material is dragged out of the building interior prior to lifting the load (see also HRCO Crane Rigging Recommendation to restrict the practice of "side pulling" loads).

[20] Outrigger systems to comply with OSHA 29 CFR 1926.452(i). Designs to be stamped and sealed by a registered NY Professional Engineer

Figure B.7.16: Acceptable Outrigger System for Material Handling Near Ground Level. Note Uninterrupted Edge Protection.

Figure B.7.17: Acceptable Outrigger System for Material Handling Near Active Floors (Top)

The 2008 New York City Building Code §3303.4.5.2 allows material to be stored while overhanging building edges provided they are sufficiently banded and braced. Although instances of code non-compliant material handling and storage practices were rare, concerns were raised regarding the potential of the current practice of material handling and storage to cause a serious incident or accident either through rigging errors, or by creating serious fall hazards (Figure B.7.18).

Also, HRCO site observations confirm that code-compliant placement and rigging of material at building edges occurs coincidentally with code non-compliant removal of edge protection (Figures B.7.19-B.7.20). Thus, edge protection is removed, creating a code non-compliant condition, to allow for the code-compliant practice of placing material at the building edge for lifting to overhead floors.

The HRCO has not identified any typical construction logistics that would preclude the use of outriggers. However, implementation of this recommendation may be benefited by providing a mechanism for contractors to elect not to use out-riggers either by special filing or for certain classes of buildings.

Figure B.7.18: Typical Unacceptable Lack of Edge Protection at Building Edge Coincident with Material Storage. Guardrails Removed over a Large Portion of This Building's Exposure to Accommodate Material Piles

Figure B.7.19: Current Code-Compliant Material Storage Practice (Piled Material is Banded and Braced) and Accompanying Fall Hazard at Unprotected Edge (Left)

Figure B.7.20: Hoisting of Debris Container (Mini) Requires Rigging Operations at Unprotected Edge. Hoisting Will Also Require Crane "Side-Pulling". Note Lack of Proper Worker Tie-Off

B.7.8 Additional HRCO Data

B.7.8.1. Construction Schedule Analysis and Violation Issuance Analysis

Two analyses were conducted to evaluate the effectiveness of violation issuances on construction quality and safety issues, and whether there is a statistically significant correlation between the frequency of violations and construction cycle time.

In summary, analysis indicates that issuing a violation has no effect on general code compliance or prevention of violation recurrence. Analysis also concluded that although construction sites with quick construction schedules are likely to contain hazardous housekeeping conditions, these same sites are not any more likely to contain hazardous safety or quality conditions than sites with slow construction schedules.

Construction Schedule Analysis

For the purposes of the HRCO study, violation categories are defined as follows:

- Housekeeping Violations: Instances where significant levels of debris accumulation exist, presenting a hazard to egress or production of falling material.

- Unprotected Edge Violations: Instances where leading edge or interior fall hazards are not properly secured per New York City code requirements. Items such as missing railings, loose fence cables, and exposed edges are considered violations.
- Tie-off Violations: Refer to instances where OSHA guidelines regarding proper Personal Fall Arrest System (PFAS) usage have been violated. Violations include failure to tie off within ten feet of an unprotected edge and failure to secure lanyards to adequate anchorage points.
- Formwork Non-Compliance: Instances where formwork design or construction creates a significant hazard to worker or public safety[21].
- Construction Quality Violations: Instances where constructed conditions are out of compliance with approved design or accepted NYC building code requirements.

The number of violations as a function of construction cycles (days) was evaluated. The construction cycle data collected by the HRCO and listed in Table 1 were analyzed to determine statistical trends between the percentage of violations and construction cycle time (construction schedule).

Table 1: Construction Cycle Data Summary

Construction Cycle (days)	Number of Samples	Housekeeping		Unprotected Edges		Worker Not Tied Off		Formwork Non Compliance		Construction Quality	
		Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage
2	15	2	13%	5	33%	6	40%	4	27%	8	53%
3	42	8	19%	14	33%	8	19%	21	50%	21	50%
4	21	3	14%	9	43%	7	33%	11	52%	4	19%
5	41	2	5%	23	56%	21	51%	9	22%	7	17%
6	9	0	0%	4	44%	2	22%	3	33%	5	56%
7	6	0	0%	2	33%	2	33%	3	50%	1	17%

[21] See High Rise Concrete Formwork Recommendations

Correlation

Analysis was performed to calculate the sample correlation coefficient, r, between the percentage of violations and construction cycle (days) for each violation category. This coefficient varies between -1.0 (perfect negative linear correlation) to 1.0 (perfect positive linear correlation). A correlation coefficient of 0 implies no correlation between the percentage of violations and construction cycle. Correlation coefficients ranged from -0.882 (negative linear correlation for “Housekeeping”) to 0.272 (positive linear correlation for “Unprotected Edges”).

Hypothesis testing was conducted using the sample correlation coefficient to determine if the population correlation coefficient, ρ, was significantly different from 0. With the exception of the “Housekeeping” category, the null hypothesis that there is no linear association between the percentage of violations and construction cycles can not be rejected at the 5% level of significance.

Hypothesis testing was next conducted using the sample correlation coefficient to determine if the population correlation coefficient, ρ, for the “Housekeeping” category was negative. The null hypothesis that there is no linear association between the percentage of “Housekeeping” violations and construction cycles was rejected at the 5% level of significance indicating that there is a strong negative correlation (e.g. the percentage of housekeeping violations decreases with an increase in construction cycle times).

Based on the correlation analysis the null hypothesis of no population correlation between construction cycles and “Housekeeping” violations can be rejected at the 5% level of significance, strongly suggesting the hypothesis of negative linear correlation.

In conclusion, there is no significant evidence of correlation between construction cycles and the percentage of “Unprotected Edges”, “Worker Not Tied Off”, “Formwork Non-Compliance”, and “Construction Quality” violations observed during the HRCO’s summer 2008 site observations

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Rank Correlation

The correlation analysis above was conducted on a relatively few number of data points (construction cycles ranging from 2 through 7 days). Statistical inference that the percentage of “Housekeeping” violations decreases with increased construction cycle days assumes that observations are sampled from a joint normal distribution and that there are no extreme observations.

A rank correlation analysis (less susceptible to the influence of extreme values) was conducted for each construction cycle category to test the null hypothesis that there is no association between the percentage of violations and construction cycles. Data were first ranked in ascending order and the Spearman's rank correlation coefficient was computed from the rankings.

Hypothesis testing was conducted using Spearman's rank correlation coefficient to determine if there is a correlation (positive or negative) between the rankings of violation percentages with construction cycles. The null hypothesis that there is no linear association between the ranked percentage of violations and construction cycles can not be rejected at the 5% level of significance. Based on the rank correlation analysis hypothesis testing, there is no statistically significant correlation (5% level of significance) between the ranking of each violation category percentage and construction cycle.

Conclusions

Two types of correlation analyses were conducted to evaluate whether there is a statistically significant sample correlation coefficient, r, between the percentage of violations and construction cycle times for each type of violation category.

The correlation analysis assumed that observations are sampled from a joint normal distribution and that there are no extreme observations. The null hypothesis of no population correlation between construction cycles and "Housekeeping" violations can be rejected at the 5% level of significance and suggests strong evidence supporting the hypothesis of negative linear correlation (decrease in the percentage of "Housekeeping" violations with an increase in construction cycle times). *There is no significant evidence of correlation between construction cycles and the percentage of Unprotected Edges, Worker Not Tied Off, Formwork Non-Compliance, and Construction Quality violations.*

B.7.8.2. Effect of Heightened Enforcement

In addition to the HRCO's standard safety observation protocol (for which jobsites were selected by a standard procedure discussed in the high-rise concrete methodology section of this report), a select group of sites was chosen to receive additional scrutiny to assess the effect of repeated enforcement. Violation timeline data were analyzed to evaluate effects of heightened enforcement and violation issuances for the following sites:

- Site No. 85, Brooklyn
- Site No. 84, Manhattan
- Site No. 56, Manhattan

- Site No. 57, Manhattan

Violation category data culled from HRCO site visits (Figures B.7.21-B.7.24) were rated as "Satisfactory", "Unsatisfactory, No Violation Issued", "Unsatisfactory, Violation Issued" and, "Stop Work Order in Effect" in Table 2.

A greater percentage of the visits with "Unsatisfactory" ratings (with or without violations issued) or stop work orders is reported for the "Formwork Compliance" (85%) and "Construction Quality" (86%) categories.

Table 2 - Visit Summary

	Number of Visits				
	Satisfactory Visit	**Unsatisfactory, No Violation Issued**	**Unsatisfactory, Violation Issued**	**Stop Work Order In Effect**	**Percent "Unsatisfactory" or Stop Work Order**
Unprotected Edges	17	20	12	0	65
Worker Tie Off	19	25	1	0	58
Housekeeping	21	12	13	0	54
Formwork Compliance	3	8	6	3	85
Construction Quality	2	8	2	2	86
Overall	62	73	34	5	64

Effect of Violations

Timeline data were evaluated to determine the effect of violations. As summarized in Table 3, the number of visits to achieve a "Satisfactory" rating averaged 2.7 visits when no violations were issued and 3.0 when violations were issued. On average, issuing violations did not decrease the number of visits to achieve a "Satisfactory" rating.

A contingency table analysis was conducted to evaluate whether there was an association or dependence between the number of repeat visits to achieve a "Satisfactory" rating and violation issuance. The "Unsatisfactory" data with or without violations were first classified as "acceptable" if a "Satisfactory" rating was achieved in one to two repeat visits or "unacceptable" if achieved in three or more visits. Data were also cross-classified by whether violations were issued or not. The cross-classified data are summarized in Table 4.

Table 3 – Number of Repeat Visits

		Satisfactory	Unsatisfactory Visit, No Violation Issued	Unsatisfactory, Violation Issued	Stop Work Order in Effect
Unprotected Edges	Count	9	20	12	
	Min.	1	1	1	
	Max.	2	9	8	
	Average	1.3	3.4	3.5	
Worker Tie Off	Count	16	22	1	
	Min.	1	1	5	
	Max.	4	6	5	
	Average	1.6	2.4	5	
Housekeeping	Count	8	12	13	
	Min.	1	1	1	
	Max.	3	5	5	
	Average	1.5	2.3	2.7	
Formwork Compliance	Count	2	2	2	2
	Min.	1	1	1	1
	Max.	1	3	2	2
	Average	1	2	1.5	1.5
Construction Quality	Count	1	1		
	Min.	1	1		
	Max.	1	1		
	Average	1	1		
Overall	Count	36	57	28	2
	Min.	1	1	1	1
	Max.	4	9	8	2
	Average	1.5	2.7	3.0	1.5

Table 4 – Violations Issued Contingency Table

	Number of Visits to "Satisfactory"				
	1 to 2		3 or More		
	Actual	Expected	Actual	Expected	Total
No Violation	34	30.8	23	26.2	57
Violation	12	15.2	16	12.8	28
Total	46		39		85

Hypothesis testing was conducted to determine if there are statistical differences between the actual and expected number of visits in the four categories of Table 4. The null hypothesis that there is no linear association between the actual and expected number of visits to achieve a “Satisfactory” rating was rejected at both the 5% and 10% level of significance, indicating that there is no statistical evidence that violations are associated with the number of visits. *Issuing a violation has no effect on reducing the number of visits to achieve a “Satisfactory” rating.*

Moving Forward

This study is limited to four sites over a limited time period. Consequently, additional investigation may be warranted to gage the effect of increased enforcement (especially stop work order efficacy). Further investigation may be performed as outlined in the following procedure.

1. Select five sites with a history of safety violations for additional scrutiny within five subject categories: Unprotected edges, Worker Tie-off, Housekeeping, Formwork Compliance and Construction Quality.

2. Confirm violation thresholds for the five subject categories, for example, establish pictorial reference standards for acceptable levels of housekeeping debris.

3. Visit each site as noted below and issue violations and stop work orders when warranted, but with a zero-tolerance policy towards infractions. For example, stop work orders for debris accumulation must still be issued even if workers were “in the process of addressing the issue”.

Table 5: Reinspection Frequencies

Floor Cycle (Days)	Minimum Visit Frequency
2	Every Two Work Days
3	Every Three Work Days
4	Every Four Work Days
5 or More	Every Work Week

4. Assess performance over a two-month period.

5. Sites with improved levels of compliance may be audited monthly to ascertain levels of continued compliance.

6. Continued, repeat non-compliance indicates insufficient deterrent levels, warranting the DOB's reevaluation of penalties. Increased violation fees and mandatory stop work orders may be effective in increasing compliance levels.

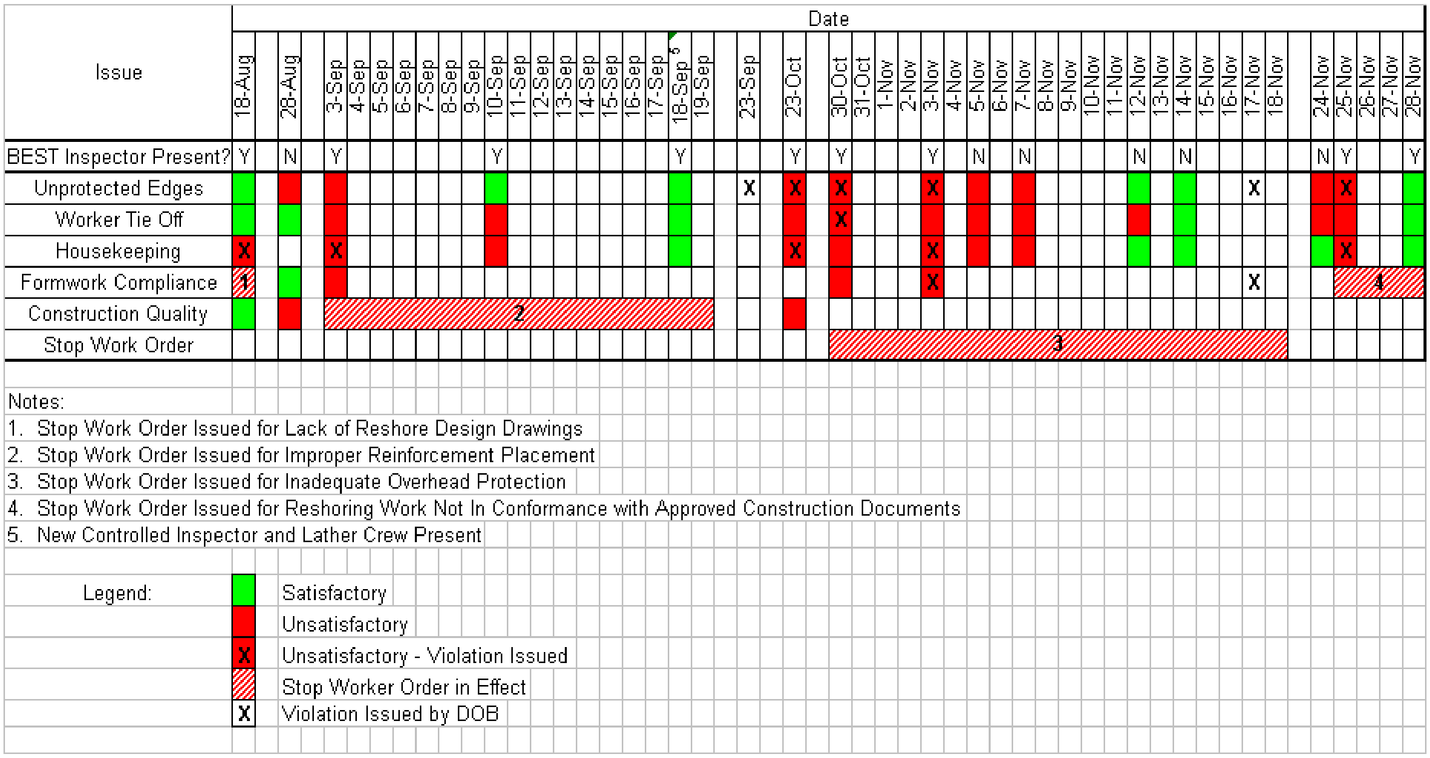

Figure B.7.21: HRCO Condition Report Timeline at Site No. 85, Brooklyn. Note Appearance of New Controlled Inspector and Lather Crew on 18-Sep.

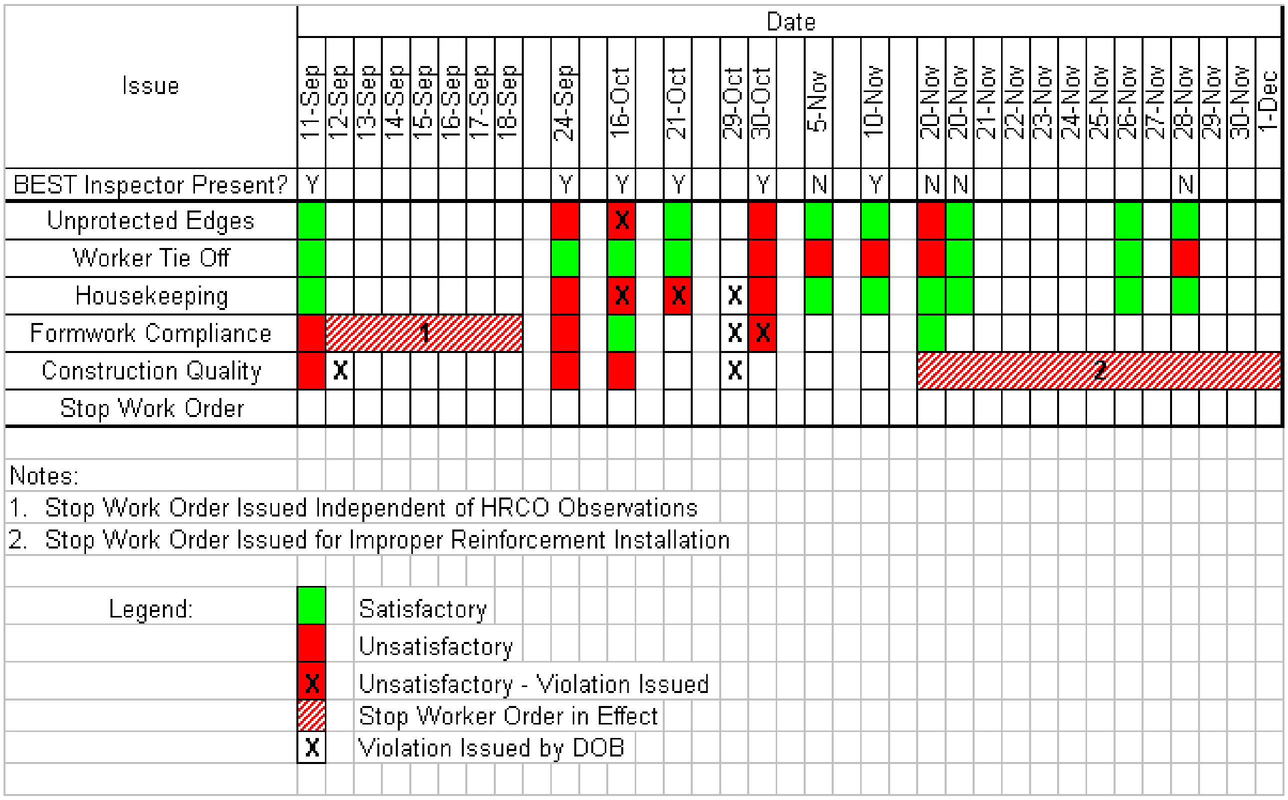

Figure B.7.22: HRCO Condition Report Timeline at Site No. 84, Manhattan

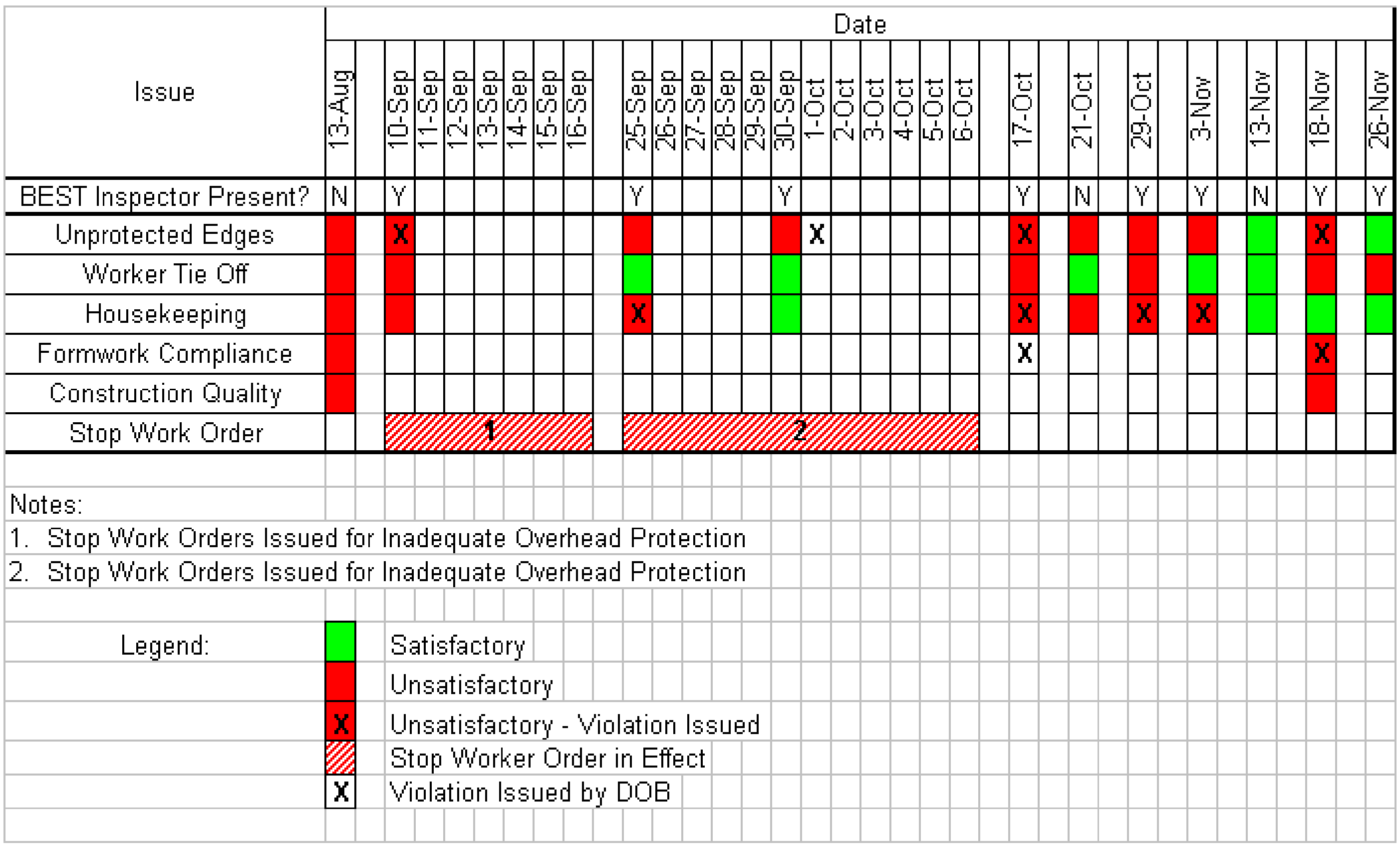

Figure B.7.23: HRCO Condition Report Timeline at Site No. 56, Manhattan

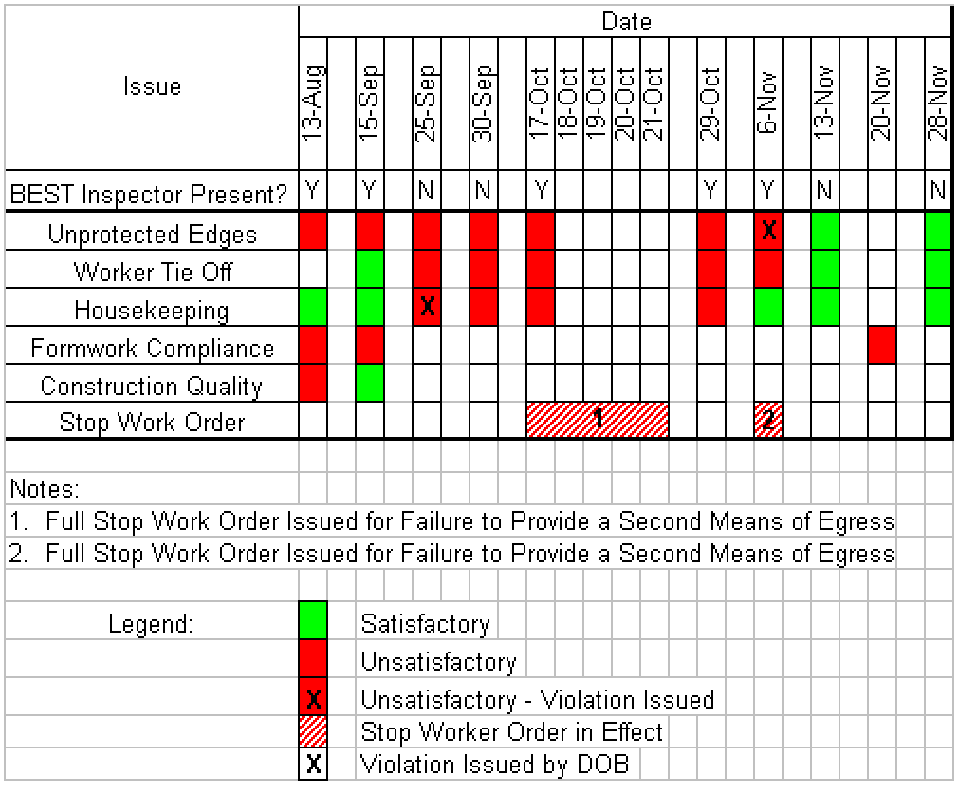

Figure B.7.24: HRCO Condition Report Timeline at Site No. 57, Manhattan

B.8 WORKER FALLS

B.8.1 Description

The High Risk Construction Oversight (HRCO) High-Rise Concrete Team observed significant numbers of safety hazards involving missing or misuse of required fall hazard protection, including tie-off safety practices (Table 1).

Existing fall-prevention requirements (edge protection, tie-offs, etc.) are currently included in the NYC Building Code and Federal OSHA CFR 1926.500 regulations. Code provisions are sufficient to mitigate these hazards; however, the provisions are routinely ignored and/or violated.

HRCO High-Rise Concrete Team observations indicate, in general, a worker's lack of basic tie-off knowledge. This lack of knowledge is typically coupled with a reluctant attitude, on the part of the worker, to comply with personal safety regulations and a relaxed approach, on the part of the contractor, to enforce proper fall protection regulations at the site. This lax attitude, on the part of the individual worker, is exacerbated at construction sites where the Site Safety Personnel's line of accountability inhibits proper enforcement of safety regulations, or where the project team does not provide the support required to execute proper safety protocols.

Table 1: HRCO Observed Fall Violations

	All Active Projects
Number of Site Observations	181
Unprotected Edges	78 (43%)
Tie-off Non-compliance	57 (31%)

Preventing fall hazard conditions, such as those during formwork operations (Figure B.8.1) can be accomplished with minimal cost when the contractor consciously anticipates safety solutions. In the case of typical site constructed dimension lumber[22] (stick) form assemblies, proper lanyard anchor points can be built into the formwork substructure and access ports for lanyards can be integrated into decking systems. The use of retractable lanyards (Figure B.8.2) can then provide adequate worker mobility throughout the entire deck area until proper guardrails are fully installed.

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[22] Typically consisting of timber posts and lumber framing members

Proper implementation of adequate OSHA and New York City Building Code compliant tie-off and edge protection practices is both realistic and achievable with current technology (Figures B.8.3- B.8.4). The cost of investment in equipment and training is insignificant in comparison to the cost of lost productivity after a preventable accident occurs. A HRCO field note entry of significance regarding existing stick form tie-off coordination practices:

- 27-Oct. 2008, Site No. 72: Tie-off anchorages used on forming floor, pulled through holes in decking.

Figure B.8.1: Failure to Tie-off During Decking Operations. Retractable Lanyards Could Have Been Utilized, Anchoring to Formwork Subassembly

Figure B.8.2: Retractable Lanyard

Figure B.8.3: Proper Tie-off. Note Use of Built-in Anchor Points on Engineered Formwork (Prefabricated Steel) Towers

Figure B.8.4: Tie-off to Formwork Substructure Using Retractable Lanyard

B.8.2 Recommendation HC-14: Fall Hazard Awareness

Implementation of a fall hazard awareness campaign through the use of posters, ads, and training at each jobsite for workers before they are allowed on site.

Worker falls at construction sites account for more fatalities than any other cause[23] (Table 2), thus any change in fall rates will have a significant impact upon fatality reduction. Continued implementation of the DOB's current fall hazard awareness campaign will be relied upon to positively effect changes to worker attitudes towards fall prevention. Similar OSHA awareness programs were able to cut fatal trenching incidents by half over a four year period.

[23] Nationwide, the Bureau of Labor Statistics attributes 442 of 1,178 (38%) construction fatalities to falls

Table 2: Historical DOB Accident-Incident Data. 2-January 2006 to 30-June 2008

	Incident	Accident	Injuries	Fatalities
All Causes, All Categories (Concrete)	1133 (132)	321 (58)	389 (63)	49 (6)
Worker Fell, All Categories (Concrete)	182 (31)	166 (28)	151 (26)	27 (4)
Worker Fell as % of All Causes (Concrete)	16.1% (23.5%)	51.7% (48.3%)	38.8% (41.3%)	55.1% (**66.7%**)

Figure B.8.5: Current NYC DOB Fall Awareness Poster

B.8.3 Recommendation HC-15: Contractor Documentation (Further Study)

Require contractor to document remedial actions taken when workers are identified as non-compliant regarding safety measures, including tie-off requirements. Remedial actions could include additional training sessions, suspension, or removal from job site.

Contractors and onsite safety team members are best equipped to identify and rectify fall hazard issues (Figure B.8.6). Furthermore, these individuals have the most at stake when an accident occurs. Therefore, conscious recognition and acknowledgement of remedial actions on the part of the contractor are warranted.

Figure B.8.6: Commonly Observed Failure to Tie-off During Formwork Erection Operations

B.8.4 Recommendation HC-16: Repeat Offense Enforcement (Further Study)

Require a "two strikes and you're out" provision to be levied against the contractor in the event the contractor fails to enforce safety regulations and procedures. This clause would require that the project is shut down a prescribed number of days after a predetermined number of code violations or reportable incidents. The purpose of the shut down is to provide the contractor a period of time to properly implement safety measures.

The threat of DOB-issued violations for code violations, such as poor housekeeping and improper tie-off procedures presenting a hazard to the public was found to be insufficient to ensure conformance to safety requirements. Also, repeat offenses are common (Figures B.8.7- B.8.9).

Figure B.8.7: Initial Failure to Tie-off at Site No. 86, 3-Sept. 2008 (OSHA Violation)

Figure B.8.8: Repeat Failure to Tie-off at Site No. 86, 10-Sept. 2008 (OSHA Violation)

Figure B.8.9: Repeat Failure to Tie-off at Site No. 86, 24-Nov. 2008 (OSHA Violation)

For example, Figure B.8.10 summarizes OSHA tie-off violations observed by the HRCO between August and November of 2008. The Department of Buildings' issuance of violations in cases where tie-off conditions presented a hazard to public safety (see 30-October entry) had limited effect on subsequent code-compliance[24].

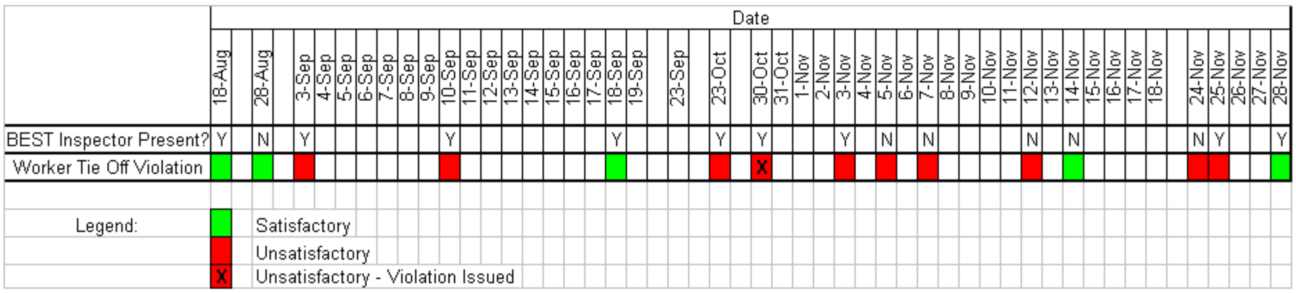

Figure B.8.10: Repeat Tie-Off Violation History, Site No. 85

Observations and interviews with construction team members, including contractors, site safety personnel, and DOB inspectors, confirm that violation fees are considered a "cost of doing business", and that the single most effective enforcement method is a stop work order. The DOB may elect to strengthen this recommendation by requiring site shut down after only one observed incidence of all types of fall hazard non-compliance (edge protection, tie-off, etc...)

[24] See General Site Safety Recommendations for additional analysis and discussion

B.9 SPECIAL INSPECTION AND CONSTRUCTION QUALITY

B.9.1 Description

The High Risk Construction Oversight (HRCO) High-Rise Concrete Team documented numerous instances of the fabrication and installation of reinforcing steel that did not comply with code requirements or industry standards. Furthermore, the HRCO High-Rise Concrete Team has observed numerous instances of inadequate and/or inconsistent inspection of installed reinforcing steel.

Of the 98 active site observations completed by HRCO engineers, forty-nine percent (49%) contained construction defects. Construction defects include New York City Building Code violations, violations of the *Building Code Requirements for Structural Concrete,* (ACI 318), and work that did not comply with the structural design drawings and/or the approved shop drawings. Deficient conditions broadly include the following:

- Improper bar placement
- Improper bar fabrication
- Ineffective special inspection

Although the HRCO site observation program noted many instances of low quality bar fabrication and placement, proper procedures were observed in New York City at both Union and Non-Union worksites. Knowledge resources such as the Lathers Union’s Queens training facility actively promote industry best practices and code-compliant installations.

B.9.2 Recommendation HC-17: Special Inspection Rule

Strengthen outreach to industry on Special Inspection qualifications, and enforce the requirement that all Special Inspectors are properly registered and/or certified in compliance with NYC Special Inspection Rule requirements, effective July 1, 2009.

Based on HRCO observations, the percentage of structures found to contain critical construction defects (Tables 1-2, Figs. B.9.1-5), despite direct oversight in each case by a controlled inspector[25], supports the actions previously taken by the DOB to improve special inspector expertise. In light of actions taken by the DOB, concerns have been raised by construction industry leaders regarding the industry's ability to provide adequate numbers of properly-qualified inspectors prior to the July 2009 deadline. Therefore the DOB's industry outreach will be critical in ensuring a smooth transition to the new inspector requirements.

Table 1: HRCO Construction Quality Defect Rate

Number of Active, Engineer-Inspected Site Observations	90
Number of Observed Quality Issues	46 of 90 (51%)
Number of Observed Quality Issues Deemed *Critical*	23 of 46 (50%)

[25] Now "Special Inspector" under The 2008 NYC Building Code

Table 2: Typical Critical Construction Defects

Improper placement of shear reinforcement
Insufficient numbers of installed shear reinforcement elements
Improper column hoop steel installation
Improper bar engagement
Severe bar congestion
Improper column splice configurations
Poor fabrication practices
Poor bar Fit-up

Figure B.9.1: Typical Critical Quality Defect: Column Splices Noncompliant with ACI. Conditions Subsequently Remedied to the Satisfaction of the Engineer of Record

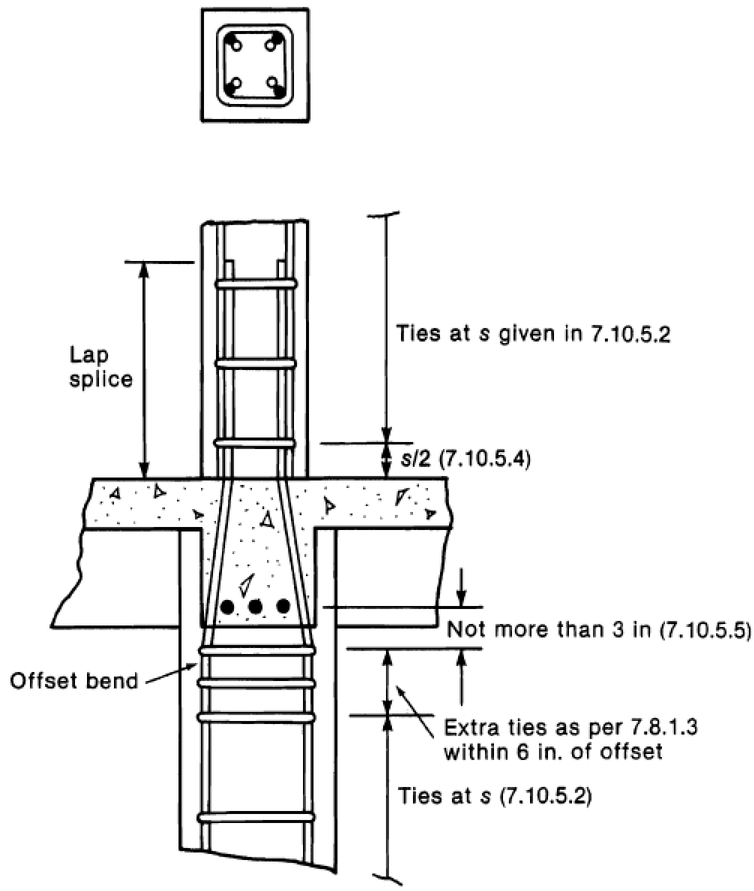

Figure B.9.2: Typical ACI-Compliant Splice Detail

Figure B.9.3: Typical Critical Quality Defect: Improper Shear Stirrup Engagement. Conditions Subsequently Remedied to the Satisfaction of the Engineer of Record

Figure B.9.4: Typical Critical Quality Defect: Bar Congestion and Improper Shear Stirrup Engagement. Conditions Subsequently Remedied to the Satisfaction of the Engineer of Record

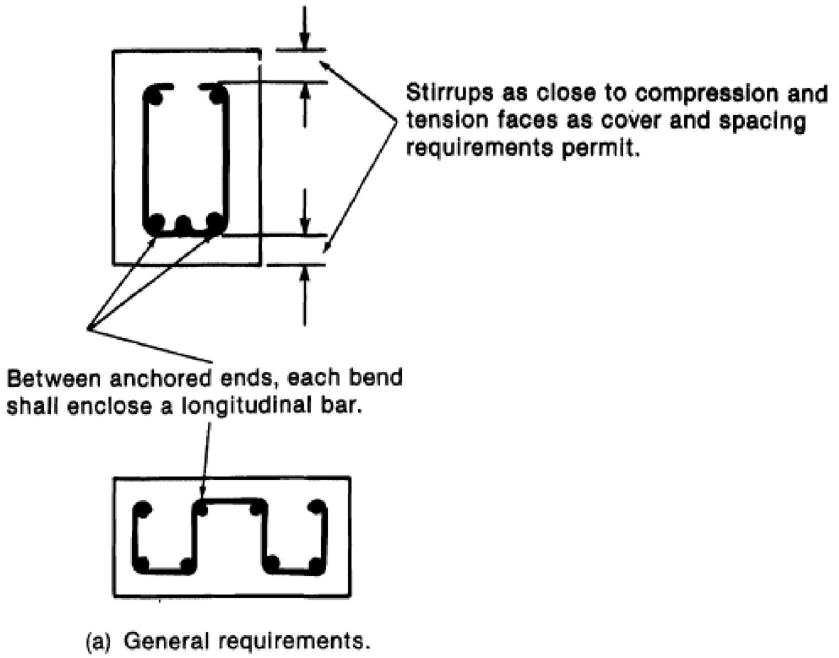

Figure B.9.5: Typical ACI-Compliant Stirrup Engagement Configurations

B.9.3 Recommendation HC-18: Field Inspection

Enhance level of knowledge among DOB inspectors to include qualifications consistent with the current NYC Building Code (Table 3), specific to ACI Special Inspector training, to promote consistent enforcement of concrete practices, including field testing procedures.

Currently, DOB inspectors generally lack sufficient training to consistently enforce critical quality issues. This is because there is no standard training procedure in place that addresses these types of issues. To appropriately enforce critical DOB construction quality code requirements, inspectors must possess a sufficient level of knowledge of the material at hand, and meet or exceed the special inspector's level of expertise in the field.

The Department of Buildings has already taken steps to certify BEST inspectors as ACI Level-1 Technicians. This education will allow inspectors to better assess the performance of field personnel responsible for sampling and approval of freshly-delivered concrete. Furthermore, ACI Level-1 training is a prerequisite to enroll in the Concrete Construction Special Inspector Program. This program covers topics critical to proper steel placement, such as tolerances, and topics critical to proper concrete consolidation.

Table 3: DOB Inspector Qualifications to Match Requirements for Special Inspectors, NYC BC 1627

		Qualifications[1,2]		
Special Inspection Category	**2008 Code Section**	**Primary Inspector or Inspection Supervisor**	**Supplemental Inspector (Alternative 1) - under direct supervision of Inspection Supervisor**	**Supplemental Inspector (Alternative 2) - under direct supervision of Inspection Supervisor**
Concrete – Cast-in-place & Precast Note: Licensed concrete testing lab to perform sampling and testing of cylinders	BC 1704.4	• PE or RA; and • 1 year relevan experience	• ACI Certification as Concrete Construction Special Inspector (ACI-CCSI) OR • ICC Certification as Concrete Special Inspector (ICC-CSI)	• ACI Certification as an Associate Concrete Construction Special Inspector (ACI-ACCSI) **Note:** ACI-ACCSI only permitted to perform inspection under on-site supervision by PE, RA, ACI-CCSI, or ICC-CSI

B.9.4 Recommendation HC-19: Inspection of Testing Labs

Enhance level of knowledge among DOB personnel to include qualifications consistent with the current NYC Building Code (Table 3), specific to ACI Special Inspector training, and other similar certifications to promote consistent inspection of laboratory practices and conditions.

Training of DOB personnel consistent with this recommendation is critical regarding the DOB's continued, periodic auditing of concrete testing laboratories for quality and code compliance. HRCO inspections have shown that laboratory quality is highly variable, with each laboratory displaying at least some level of non-conformance with code-required testing procedures (see section B.3.2). Additionally, as the DOB will require testing laboratories to obtain AASHTO[26] accreditation by July of 2010, it will be necessary for the DOB knowledge base to

[26] American Association of State Highway and Transportation Officials

remain current with AASHTO requirements through education and training programs.

B.9.5 Recommendation HC-20: Reinforcing Bend Quality Assurance

Require documentation through photo and/or video that site bending practice complies with accepted industry standards and tolerances. Conformance may be spot checked by the DOB through inspection of logs and field conditions.

HRCO engineers observed numerous instances of fabricated reinforcing that did not conform to industry standards[27] as dictated by The New York City Building Code (Figures B.9.6- B.9.7). A failure of the construction industry to provide quality bar fabrication resulted in this recommendation since improper bar fabrication is likely to introduce critical structural defects.

Augmentation of the special inspector’s existing daily reporting documents to include photo documentation of proper and consistent bend quality would allow the Department of Buildings to verify that best bending practices in conformance with code requirements are being utilized regularly. Without this type of documentation (and without constant observation by a DOB inspector), the DOB will be unable to confirm that improved procedures are being enacted.

[27] Specifically American Concrete Institute (ACI) Requirements

Figure B.9.6: Improperly Fabricated Shear Stirrups, Resulting in Improper Stirrup Engagement. Conditions Subsequently Remedied to the Satisfaction of the Engineer of Record

Figure B.9.7: Bar Fabrication Noncompliant with ACI[28]. Conditions Brought to the Attention of the Engineer of Record

B.9.6 Recommendation HC-21: Reinforcing Placement Quality Assurance

Require documentation through photo and/or video that steel placement complies with accepted industry standards and tolerances. Conformance may be periodically spot checked by the DOB through inspection of construction logs and field conditions.

HRCO engineers observed numerous instances of installed reinforcing that did not conform to the design documents, the approved shop drawings, or industry-standard code requirements (Figures B.9.8- B.9.10). A failure of the construction industry to monitor, install, and provide quality bar placement resulted in this recommendation since improper bar placement and installation will likely introduce structural defects, some of which may be critical.

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[28] Bend Radius is Tighter than Allowed by American Concrete Institute (ACI) Specifications

The justification to augment the special inspector's existing daily reporting documents to include photo and/or video documentation of bar placement is twofold. One, the Department of Buildings will be able to verify upon review of the documentation that bar placement is in conformance with code requirements (without the need for constant on-site observation by a DOB inspector); and, two, the documentation will allow review of constructed assemblies by design professionals if placement questions arise.

Figure B.9.8: Lack of Proper Shear Stirrup Engagement. Condition Soon to be Hidden by Concrete Encasement. Conditions Brought to the Attention of the Engineer of Record

Figure B.9.9: Column Bar Congestion. Conditions Brought to the Attention of the Engineer of Record

Figure B.9.10: Severe Bar Congestion[29]. Conditions Brought to the Attention of the Engineer of Record

[29] American Concrete Institute Specifications Require Minimum Spacing Between Bars, Greater of One Inch or Diameter of Bar to Allow for Proper Concrete Consolidation

B.9.7 Additional HRCO Data

Table 4: Sites with Critical Quality Defects

Address	Boro	Notes
3	B3[30]	Insufficient stirrup Engagement.
4	B1[31]	Insufficient stirrup engagement
14	B1	Insufficient stirrup engagement. Bar Congestion
14	B1	Improper hook fabrication
15	B1	Insufficient stirrup engagement. Improper column tie fabrication and installation
45	B1	Improper Splice Configurations, Improper Bending of Embedded Steel
48	B1	Improper Splice Configurations, Improper Bending of Embedded Steel. Bar Congestion
55	B3	Insufficient Column tie engagement. Improper hook fabrication. Improperly placed column bars
67	B1	Improper Splice Configurations, Improper Bending of Embedded Steel
72	B1	Improper Splice Configurations, Improper Bending of Embedded Steel
72	B1	Improper stirrup Engagement
74	B1	Bar Congestion. Insufficient stirrup engagement. Improper column bar placement. Improper splice configurations
84	B1	Improper Splice Configurations. Insufficient stirrup engagement
84	B1	Improper Splice Configurations, Improper Bending of Embedded Steel

[30] Borough of Brooklyn

[31] Borough of Manhattan

84	B1	Improper Splice Configurations, Improper Bending of Embedded Steel
85	B3	Improper Stirrup Engagement. Improper hook fabrication. Improper column and wall tie engagement
40	B1	Improper placement of shearwall reinforcement, insufficient bar encapsulation
47	B1	Insufficient numbers of shear stirrups installed at transfer beams. Misinstalled shear reinforcement
58	B1	Improper placement of column tie and shear reinforcement
83	B1	Improper stirrup configurations at grade beam

B.9.8 Impact of Construction Quality Deficiencies

Proper construction and inspection procedures will significantly improve construction quality related to load carrying capacity of structural members. Defects in construction quality may remain unrealized for years or decades as the applied load is generally less than the design load. However, it is likely that a critical loading event could occur during the life of the structure resulting in distress or collapse (e.g. wind loads from a major hurricane). An example to justify the need for proper inspection oversight is illustrated below.

- On 25-September, 2008, HRCO staff observed three, second floor transfer girders with ACI-noncompliant shear steel engagement[32] (Figure B.9.11). As constructed, only two of the six shear stirrup legs at the beam soffit were properly hooked around longitudinal reinforcement. Preliminary calculations indicate this bar configuration would have resulted in a 33% reduction in beam shear capacity. This reduced shear capacity could have resulted in serviceability and/or durability issues or, possibly structural failure. A DOB stop work order was put in place until the beams were certified complete and corrected to the satisfaction of the engineer of record.

- Although an initial review of shop and design drawings confirmed sufficient numbers of bottom longitudinal bars, the contractor missed drawing notes requiring the anchorage of all shear hooks with additional steel. A properly trained special inspector would likely have identified not only the noted additional steel requirements, but easily brought the readily-observable code noncompliant conditions to the attention of the contractor and engineer.

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[32] ACI-318 §12.13.2.1

Figure B.9.11: Second Floor Transfer Girder with Improperly Developed Shear Reinforcing. Site No. 47

- The same site was visited on 10-October, 2009 and the girder configurations were compared to the stamped design drawing. At this time HRCO staff noted two second floor transfer girders with insufficient numbers of installed shear stirrup sets (Figure B.9.12), bar congestion (Figure B.9.13), and insufficient numbers of installed longitudinal beam top bars. Of the specified 67 sets of shear reinforcement, only 47 sets were installed. Similar to the prior incident, a stop work order was put in place by the DOB until corrective actions could be taken to the satisfaction of the Engineer of Record. Preliminary calculations indicate that shear capacity resulting from this configuration was reduced by 20%. Furthermore, the combined effects of both the September and October defects would have resulted in a shear capacity loss of 44% had these conditions not been remediated.

- Again, it is likely a properly trained special inspector would have identified the egregious lack of sufficient numbers of reinforcing bars, and brought this condition to the attention of the contractor and engineer.

Figure B.9.12: First Floor Transfer Girder with Insufficient Numbers of Installed Shear Reinforcing Sets. Site No. 47

Figure B.9.13: First Floor Transfer Girder Bar Congestion. Site No. 47

B.10 PLAN REVIEW

B.10.1 Description

The High Risk Construction Oversight (HRCO) High-Rise Concrete Team reviewed a number of construction document sets containing structural engineering drawings that had been submitted to the DOB as part of the permitting process. Furthermore, HRCO team members performed a review of the existing NYC Building Code provisions pertaining to construction document and peer review requirements.

Review of construction documents identified structural design drawings containing incomplete information according to generally accepted industry standards such as American Concrete Institute (ACI) document entitled *Building Code Requirements for Structural Concrete,* ACI 318, ACI document entitled *Details and Detailing of Concrete Reinforcement*, ACI 315 and the *Manual of Standard Practice* published by the Concrete Reinforcing Steel Institute. Incomplete drawing information severely hampers both the construction and peer review processes, is potentially indicative of a substandard level of quality of the structural design work, and could potentially lead to structural integrity and life safety issues in the constructed building.

To the extent that many jurisdictions outside New York City practice high levels of structural design review, the precedent for increased levels of oversight has been established. Responses to the HRCO's benchmark survey (Table 1) suggest New York City's adoption of more stringent plan review criteria would be in line with other building departments nationwide.

Table 1: Plan Review Practices

Respondent	Percentage of Major Projects Subjected to Detailed *Structural* Review	Percentage of Major Projects Subjected to Partial *Structural* Review
Boston	-	100
Chicago	99	-
Fairfax County	-	100
Honolulu	-	100
Los Angeles	100	-
Philadelphia	100	-
San Diego	100	-
San Francisco	100	-
San Jose	100	-
Seattle	-	100
Toronto	-[33]	90

B.10.2 Recommendation HC-22: Monitoring of Peer Review

Retain professional engineers on behalf of DOB to monitor that peer reviews of identified projects are properly conducted as required by the NYC Building Code.

Peer review, by an independent structural engineer, is an essential component of the design and construction process and is standard practice in many jurisdictions. A majority of major buildings[34] may qualify for peer review under the current criteria[35] contained in the NYC Building Code. This criteria includes, in part:

1. Buildings in Occupancy Category IV or more than 50,000 SF of framed area.
2. Buildings with aspect ratios of seven or greater
3. Buildings greater than 600 feet in height or more than 1,000,000 SF gross floor area

[33] Remaining 10% Self Certified by Design Professional

[34] 2008 NYC Building Code BC 3310

[35] 2008 NYC Building Code BC 1627

4. Buildings taller than seven stories where any element supports in aggregate more than 15% of the building area

5. Buildings designed with non-linear analysis

6. As requested by the Commissioner

The identification of structures qualifying for peer review under requirements of BC 1627 requires a structural engineering background, and the number of structures that qualify for peer review may be significant. Therefore, at least one full-time, qualified structural engineer working either on staff or on behalf of the DOB will be required to oversee peer review work. This oversight should include the following:

- Positive identification of structures meeting thresholds for peer review.

- Monitoring of peer review submission procedures.

- Periodic auditing of completed peer reviews for quality and completeness

In addition, the DOB may elect to develop programs for identification of critical structural members not currently addressed in BC 1627 for review, and screening of projects submitted for plan examination approval to prioritize for structural plan review.

B.10.3 Recommendation HC-23: Structural Drawing Information

Require minimum level of information to be included on structural building drawings, including member end reactions and details with sufficient information to properly convey the design intent.

Current DOB plan review procedures do not include technical review sufficient to identify adequacy as prescribed by the NYC Building Code. Furthermore not all sets of structural drawings contain sufficient levels of design information.[36] In addition to existing requirements, and in order to facilitate the peer-review process, the following additional information should be required.

- Member end reactions, including flexure, shear, and axial reactions will be noted on the structural drawings for major structural members such as transfer girders, beam girders, and shear walls.

- Details, and detailing, consistent with ACI 315, Part A

[36] 2008 NYC Building Code BC 1603 and BC 106.7

- Sufficient notes and details to properly convey the design intent.

B.10.4 Recommendation HC-24: Monitoring of Structural Information Quality

DOB should retain professional structural engineers to review drawings to verify that the minimum level of structural information is contained on each set of structural drawings, shop drawings, and formwork drawings. Information to include requirements contained in ACI publications as noted in current NYC Building Code.

The volume of plan submissions is significant; therefore, a monitoring program supervised by at least one qualified, full-time structural engineer with sufficient practical design experience is warranted. This program is warranted based on practices in major municipalities (Table 2). While this review is best executed by the owner, the City of New York should maintain sufficient in-house resources to audit a percentage of completed reviews.

Table 2: Engineering Staff

Respondents with Significant Structural Plan Review Programs	Number of Full Time Staff Engineers	Percentage of Reviews Performed In-House
Boston, MA	1	50%
Chicago, IL	4	25%
Fairfax County, VA	5	NA
Honolulu, HI	2	90%
Los Angeles, CA	140	NA
Philadelphia, PA	11	100%
San Diego, CA	24	NA
San Francisco, CA	25	100%
San Jose, CA	18	75%
Seattle, WA	15	85%
Toronto, Canada	18	NA

B.10.5 Recommendation HC-25: Monitoring Constructability

DOB should retain professional structural engineers to audit and verify that a sufficient, minimum level of details and detailing is included on each set of structural drawings and shop drawings. Minimum level of detailing to comply with requirements of ACI publications as noted in current NYC Building Code.

Current Department of Buildings plan review procedures do not include technical review of constructability; therefore, design drawings submitted by design professionals often lack consideration of overall constructability. Including a sufficient level of proper detailing on structural drawings will minimize onsite confusion, increase construction efficiency, and reduce potential structural defects and inadequacies resulting from designed-in bar congestion (Figure B.10.1- B.10.3).

A monitoring program supervised by a qualified engineer familiar with practical construction sequencing considerations is warranted based on practices in major municipalities. Optimally, this professional would have experience as a constructability analyst for a general contractor, in addition to considerable design experience. Similar to the structural quality review recommendation, the city should maintain in-house staff sufficient to audit a percentage of completed constructability reviews.

Figure B.10.1: Splice Condition Requiring Additional Information from the Engineer of Record.

Figure B.10.2: Constructability Issues at Beam-Column Connection

Figure B.10.3: Constructability Issues at Transfer Beam top bars

Appendix B.1: Site Observation Log

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
1	BKLYN	Y	8-Aug-08	Full	NO	UNK	17	No Inspector						
2	MNHTN	UNK	6-Oct-08	Full	NO	UNK	UNK	No Inspector						
3	BKLYN	Y	18-Aug-08	Full	YES	UNK	52	YES						Engineer's concrete specifications limit stripping time to minimum of 48 hours under best conditions with type III cement. Stripping occurring at 24 hours. Quality control of rebar bends low, poor fitup, haphazard bending procedures, especially in stirrup fabrications. special inspector not qualified. has little knowledge of ACI requirements
4	MNHTN	Y	4-Sep-08	Full	YES	3	57	YES						Contractor inspects formwork, but keeps no record. Formwork design called for 9 floors of reshores, only 2 currently reshored
4	MNHTN	Y	23-Sep-08	Full	YES	3	57	YES						Incomplete formwork design, some missing and insufficient netting. Housekeeping. Bracing removed day of pour. Reshores removed in areas
4	MNHTN	Y	15-Oct-08	Full	YES	3	57	YES						Violation issued for Housekeeping, not effective. Housekeeping still found to be major issue. No inspection of rings. Concrete sampling not ASTM compliant. Inspector not on site during pours.
4	MNHTN	Y	14-Nov-08	Full	YES	3	57	NO						Incomplete form inspection logs. Missing some fencing on stripping floor. Excessive scrap rebar in bottom of forms. Stirrup engagement issue observed, corrected by inspector onsite
4	MNHTN	Y	24-Nov-08	Targeted Safety	YES	3	57	No Inspector						Vertical netting

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5	MNHTN	Y	20-Aug-08	Full	YES	UNK	25	No Inspector						Concrete construction completed. Special inspector reports not available for worked completed after December 2007. General contractor stated he used a "rule of thumb" to determine the amount of reshores needed, number of floors to reshore, and when to remove reshores.
6	MNHTN	N	9-Sep-08	Full	YES	UNK	19	No Inspector						
7	MNHTN	Y	27-Aug-08	Targeted Safety	YES	UNK	53	No Inspector						
7	MNHTN	Y	19-Nov-08	NA	NO	UNK	UNK	No Inspector						
8	MNHTN	Y	22-Sep-08	Targeted Safety	NO	UNK	35	NA						Excavation Only
8	MNHTN	Y	29-Sep-08	Full	YES	UNK (Foundation)	35	No Inspector						No controlled inspection notes on design. Stripping sequence shown on structural notes
9	MNHTN	N	16-Sep-08	Full	YES	UNK	10	YES						Steel Building. Workers not tied off when flying material. Inspector log not onsite
10	MNHTN	Y	7-Oct-08	Targeted Engineering	YES	2	42	No Inspector						
11	MNHTN	Y	12-Nov-08	Targeted Safety	YES	3	15	No Inspector						Worker not tied off.
11	MNHTN	Y	18-Nov-08	Full	YES	10	15	YES						No reshore drawings. No Shop drawings. No Curing box.
12	MNHTN	Y	25-Sep-08	Full	NO	UNK (Demolition)	14	NO						Existing structure still in use
13	MNHTN	Y	21-Aug-08	Full	YES	UNK	18	No Inspector						No Stamped formwork Design, marked "Preliminary, Not for Construction"

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14	MNHTN	Y	7-Oct-08	Full	YES	2	42	NO						Shear engagement deficiencies in beam. Condition accepted by Engineer's representative onsite and by inspector. Lateral bracing removed from formwork immediately after placement. Letter allowing this practice, stamped by PE formwork designer.
14	MNHTN	Y	5-Nov-08	Full	YES	3	43	NO						Improperly fabricated hooks voluntarily replaced by contractor with correct sets. Concrete testing not in conformance with ASTM. Forms stripped prior to knowledge of concrete strength as noted in project specifications.
15	MNHTN	Y	29-Sep-08	Full	YES	2	20	NO						Per contractor, no form inspections performed. Poor internal access due to housekeeping. Formwork post spacing not in conformance or secured. Controlled structural inspector has ACI level 1 Certification. No controlled inspection logs. No formwork sequences. No knowledge of concrete strength prior to stripping. Improperly installed stirrups. Improper fabrication. Improper column tie installation
15	MNHTN	Y	17-Nov-08	Full	YES	3	20	YES						Incomplete formwork design (missing details for thicker 22" slab). Housekeeping. Workers not tied off on stripping floor. Missing daily safety logs. Rebar placement not in conformance with design, corrected during visit. Inspector not able to catch misplacements. Improper formwork bracing installation.

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16	MNHTN	Y	28-Oct-08	Full	YES	2	26	YES						Form bracing not installed per drawings. No form stripping sequence available.
16	MNHTN	Y	29-Oct-08	Targeted Concrete Testing	YES	UNK	26	No Inspector						Concrete testing not in conformance with ASTM
17	MNHTN	N	16-Sep-08	Full	YES	UNK	14	NO						Egress issues, fencing
18	MNHTN	Y	25-Sep-08	Full	NO	UNK (Demolition)	21	NO						Demolition of existing structure in progress
19	BKLYN	Y	19-Aug-08	Full	YES	UNK	15	YES						Work performed while the General Contractor and Concrete Superintendent were not on the job site. Per Site Safety Manager, all documentation located in GC trailer and not available for review.
19	BKLYN	Y	3-Sep-08	Full	YES	UNK	17	YES						Formwork installation not in conformance with design documents. No design for cantilevered work platform. No Stripping Sequence Available. Improper shearwall rebar installation
19	BKLYN	Y	1-Oct-08	Full	NO	UNK (No Activity)	15	No Inspector						Site Closed
20	MNHTN	Y	15-Sep-08	Targeted Safety	YES	7	19	YES						Workers not tied off, or improperly tied to handrails
20	MNHTN	Y	16-Sep-08	Full	YES	7	19	YES						Formwork bracing not in conformance with design. Improper shoring posts (#3 instead of #4). Controlled inspector for steel is ACI level 1 certified.
20	MNHTN	Y	17-Sep-08	Targeted Safety	YES	7	19	YES						Unprotected interior openings and sidewalk shed non compliance. Improper tie-off procedures
20	MNHTN	Y	18-Sep-08	Targeted SWO Reinspection	YES	7	19	YES						

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20	MNHTN	Y	23-Sep-08	DOB requested visit for information	YES	7	19	No Inspector						
20	MNHTN	Y	5-Nov-08	Targeted Safety	YES	7	19	No Inspector						Incomplete Site Safety Log
21	MNHTN	Y	30-Jul-08	Full	YES	5	20	No Inspector						Single Legged Stirrups not engaged at bottom
21	MNHTN	Y	4-Sep-08	Full	YES	5	20	NO						Formwork drawing for 19th floor not available
22	MNHTN	Y	21-Oct-08	Full	YES	UNK (Excavation)	15	NO						Stamped structural set has no general notes. Site does not comply with Site Safety Plan. Missing netting, fencing and blocked exit. Site Safety Personnel not effective.
23	BKLYN	Y	19-Aug-08	Full	YES	UNK	30	YES						Inadequate site safety meetings. Unsafe electrical panel cover. Inadequate rebar protection. Standing water in basement. Special inspector records not available for review
23	BKLYN	Y	1-Oct-08	Full	YES	9	30	No Inspector						Owner-hired Site Safety Manager, observed good safety response over contractor hired Site Safety Manager. Safety glasses needed. Formwork sequences NA. No contractor knowledge of concrete strength at time of stripping. Reshores removed prior to verification of required strength.
23	BKLYN	Y	12-Nov-08	Full	YES	4	31	YES						Incomplete Form inspection logs. Reshoring of balconies not in conformance with drawings.
24	MNHTN	Y	5-Aug-08	Full	YES	UNK	51	No Inspector						Serious lack of edge protection noted. EOC Contacted
24	MNHTN	Y	6-Aug-08	Full	YES	UNK	51	No Inspector						Edge conditions noted previous day, some not corrected by subsequent BEST squad inspection
25	MNHTN	Y	26-Aug-08	Targeted Safety	NO	UNK	UNK	No Inspector						

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26	MNHTN	Y	7-Oct-08	Targeted Safety	YES	UNK	19	No Inspector						
27	MNHTN	N	6-Oct-08	Full	NO	UNK (Masonry)	10	NO						Masonry/steel building
28	BKLYN	Y	3-Nov-08	Targeted Safety	NA (Excavation)	UNK (Excavation)	25	NO						
29	BKLYN	Y	27-Aug-08	Full	YES	2	30	NO						Form bracing not installed in conformance. Controlled rebar inspector has ACI grade 1 certification. Placement approvals not written. Poor inspector qualifications and knowledge. Scaffold used as controlled egress and overhead protection, allowed by code. Housekeeping. Worker not tied off.
29	BKLYN	Y	24-Sep-08	Targeted Safety	YES	2	30	No Inspector						Fall hazards throughout. Workers not tied off. Additional concrete contractor's safety personnel onsite, but ineffective. Workers without hardhats
29	BKLYN	Y	1-Oct-08	Full	YES	2	30	No Inspector						Housekeeping improved since last visit. Bracing Removed during concrete placement. Workers without hard hats
29	BKLYN	Y	13-Nov-08	Full	YES	UNK	30	YES						Incomplete form inspection logs. No reshore sequence design. No Concrete tester on site during pour, work stopped until he arrived
30	MNHTN	N	22-Sep-08	Targeted Engineering	YES	11	12	No Inspector						No Formwork inspection logs. No Site Safety logs. No Bracing Design. Incomplete formwork design. Controlled inspection reports not available, no approved column shops. Misinstalled vertical netting. Worker not tied off
31	BKLYN	Y	8-Aug-08	Full	NO	UNK	25	No Inspector						

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32	MNHTN	UNK	23-Sep-08	Not Active	NO	UNK	UNK	NO						Loose railings
33	BKLYN	Y	27-Aug-08	Targeted Engineering	YES	3	21	YES						Misinstalled shearwall ties previously approved by inspector. Brought to attention of controlled inspector, he voluntarily rescinded his approval and GC cancelled pour.
33	BKLYN	Y	8-Sep-08	Targeted Safety and Engineering	YES	3	21	No Inspector						Formwork towers not installed per drawings. Excessive spacings and insufficient numbers of lateral bracing elements
33	BKLYN	Y	23-Oct-08	Full	YES	3	21	YES						Missing shoring towers. Improper placement of towers. Good splicing configurations. Improperly engaged shear stirrups
33	BKLYN	Y	24-Nov-08	Targeted Safety	YES	3	26	YES						Limited tie off compliance. Adjacent building protection. Violation should have been issued for tie off compliance
34	MNHTN	Y	2-Oct-08	Full	YES	14	45	YES						No Formwork inspection Logs. No Controlled inspection Logs available after March '07. Sequence and timing of formwork cracking not available in formwork design. 2 day cycle in use prior to formwork collapse in Jan. '08
35	MNHTN	N	9-Sep-08	Full	NO	UNK	UNK	No Inspector						Not active
36	MNHTN	Y	14-Oct-08	Full	YES	4	20	YES						Workers without hard hats
36	MNHTN	Y	30-Oct-08	Targeted Safety	YES	3	20	No Inspector						Workers not tied off on stripping deck near edge. Housekeeping
36	MNHTN	Y	7-Aug-08	Full	YES	4	20	No Inspector						

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36	MNHTN	Y	2-Sep-08	Full	YES	4	20	No Inspector						Insufficient number of reshored floors at 15th floor slab around the elevator core. Worker Not tied off on 19th floor. Concrete test results not available for concrete cast after July 16, 2008. Stripping floor has no edge protection. No formwork stripping sequence available
37	MNHTN	N	10-Sep-08	Full	YES	UNK	9	YES						Multiple Safety violations including perimeter fall protection. Exposed staircases throughout. Unprotected edges at forming floor, workers not tied off. No reshoring design, reshores not in conformance with minimum spacings. Unknown number of required reshored floors
37	MNHTN	N	22-Sep-08	Targeted Safety	YES	8	10	YES						SWO issued 9/10 for formwork.
38	MNHTN	Y	23-Sep-08	Targeted Safety	NO	UNK	19	No Inspector						Active Excavation
38	MNHTN	Y	25-Sep-08	Full	NO	UNK (Excavation)	19	NO						
39	MNHTN	N	23-Sep-08	Full	NO	UNK	6	NO						Site safety personnel could not direct railings to be fixed during visit.
40	MNHTN	N	2-Oct-08	Walk Through	YES	6	12	No Inspector	NA	NA	NA	NA	NA	Tie-off violations observed at unprotected outrigger. Noted safety improvements since yesterday's visit. Contractor comments that BEST inspections helpful so long as they are consistent in enforcement. Site Safety person effective. Conversations with Site Safety personnel indicate preference is to be hired by owner, owner involvement improves ability to enforce safety regulations.

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40	MNHTN	N	14-Oct-08	Full	YES	6	12	YES						Workers not tied off. Improper formwork tie-down installation.
40	MNHTN	N	30-Oct-08	Full	YES	6	12	YES						Supplemental letter from engineer addresses reshoring sequences.
40	MNHTN	Y	28-Aug-08	Targeted Safety	YES	6	12	UNK						No Site Safety plan onsite. No Site Safety log onsite. Unprotected edges at interior.
40	MNHTN	Y	4-Sep-08	Full	YES	6	12	YES						West shearwall steel tied to stayform system preventing proper cover and encapsulation of rebar. Site Safety Plan not submitted to BEST. Lack of sufficient edge protection
41	MNHTN	Y	18-Sep-08	Targeted Safety	YES	UNK	18	YES						Partially poured shearwall concrete being hacked out with crowbar, planned to re-pour same day without proper removal and cleaning.
41	MNHTN	Y	28-Oct-08	Full	YES	UNK	18	No Inspector						Guardrails at stairs. Egress. Good Quality prefabbed bends in bars, specially offset for splices. Good formwork practices.
41	MNHTN	Y	2-Sep-08	Full	YES	UNK	18	YES						Formwork drawing not stamped by PE. Restricted egress from basement level. Worker not tied off. Insufficient edge protection on forming floor
41	MNHTN	Y	25-Sep-08	Reinspection	YES	UNK	18	NO						Reinspection per DOB request for existing SWO. Repairs in general conformance with violation requirements. Excessive debris in forms. BEST to reinspect debris removal
41	MNHTN	Y	30-Oct-08	Targeted Engineering	YES	4	18	NO						Concrete testing not performed per ASTM
42	MNHTN	Y	7-Aug-08	Full	NO	UNK	-	No Inspector						

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43	MNHTN	Y	21-Aug-08	Full	YES	UNK	20	YES, Through EOC						Multiple safety violations observed including, egress, unprotected openings, perimeter leading edge protection. Site Safety Manager not present on site for extensive period while under inspection. Timing of formwork stripping in direct violation of specifications. Overall sub par coordination and handling of men and material throughout site. Workers not tied off on stripping floor. Internal stirrups not engaged
44	MNHTN	Y	2-Sep-08	Full	YES	UNK	20	No Inspector						Formwork drawing is for second floor, but was used throughout for construction. Workers not tied off at multiple locations. Debris and material throughout.
45	MNHTN	Y	26-Aug-08	Targeted Safety	YES	UNK	34	No Inspector						Underpinning questionable. Excavation team called for inspection.
45	MNHTN	Y	19-Nov-08	Full	YES	UNK (Excavation)	34	YES						Site Safety Plan out of date. Public construction barriers and railing issues. Improper formwork installations. Non code compliant splices, inspector only on site day of pour.
46	MNHTN	Y	10-Sep-08	Targeted Safety	YES	UNK	39	YES						Site Safety Manager not initially on Site. General safety issues, security, fall hazards
46	MNHTN	Y	20-Nov-08	Full	YES	5	39	No Inspector						Formwork installation not in conformance with design documents. Insufficient guardrail installations

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47	MNHTN	N	17-Nov-08	Full	YES	6	8	YES						No Competent safety personnel on site. No site safety logs. Many missing guardrails. Improper adjacent site protection. No knowledge of concrete strength prior to stripping. Improper edge post installation. Unprotected openings
47	MNHTN	N	25-Sep-08	Full	YES	6	8	YES						Formwork design not stamped, may not be required. No formwork inspections performed. No EOR inspections performed for structure. Improper post installations. Lack of engagement between transfer girder flexural and shear steel (three girders). Rebar placement at these girders approved by inspector. Insufficient number of bars available to engage shear steel (design/detailing issue). Incomplete netting installation
47	MNHTN	N	10-Oct-08	Targeted reinspection	YES	6	8	YES						Engagement issues fixed. Now missing ~20 of 67 pairs of shear stirrups. Insufficient top steel. Congestion at splices
47	MNHTN	N	15-Oct-08	Targeted reinspection	YES	2	8	NO						Steel Issues Corrected
48	MNHTN	Y	22-Oct-08	DOB Requested Incident Follow-up	NO	6	35	NO						Follow up to DOB reported formwork collapse. No collapse observed onsite. (2) 2x3 ribs blown out of building by high winds. Vulnerable formwork deck at leading edge removed by contractor. Observed steel and formwork non-compliance insufficient bracing. Follow up with BEST squad same day. Site Safety Manager observed that they are more successful on project where they are retained by the owner.

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48	MNHTN	y	22-Oct-08	Full	YES	3	35	YES						Sidewalk barriers not in conformance with Site Safety plan. Housekeeping. Workers not tied off during crane jumping. Missing formwork bracing per drawings. Cold bent embedded bars and bar congestion. No record of repairs for similar deficiencies on previous floors.
49	MNHTN	Y	18-Sep-08	Full	YES	4	22	NO						Incomplete reshoring design (no reshoring sequence). Missing bracing detail. Improper railing height
50	MNHTN	Y	17-Oct-08	Full	YES	3	25	No Inspector						Lateral form brace removal during pour. No form inspection log. No approved shop drawings. Concrete sampling not in conformance with ASTM. No knowledge of concrete strength prior to stripping.
51	MNHTN	UNK	22-Sep-08	Full	NO	UNK	UNK	NO						Empty Lot
52	MNHTN	UNK	17-Sep-08	-	NO	UNK	UNK	NO						Closed site
53	MNHTN	Y	20-Aug-08	Full	NO	UNK	20	No Inspector						Concrete construction completed. Formwork drawings no longer on site
54	BKLYN	Y	5-Aug-08	Full	NO	UNK	10	No Inspector						
55	BKLYN	Y	19-Aug-08	Full	YES	3	15	YES						Column ties not closed with proper hook. Column ties not present at beam column intersection. Column ties not engaged. Inadequate column bar placement. Bracing removed in violation of general notes. Not enough shored floors.
55	BKLYN	Y	27-Aug-08	Targeted Engineering	YES	3	15	No Inspector						Controlled inspector has little knowledge of code requirements, has ACI grade I certification.

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55	BKLYN	Y	8-Sep-08	Full	YES	3	15	YES						Edge Protection not sufficient. Insufficient numbers of lateral braces installed below forming floor. Most braces not secured to deck. Reshoring and stripping of formwork not per designer's general notes. Memo issued by designer, implies general notes are "suggestions". Top steel congestion at columns
55	BKLYN	Y	24-Sep-08	Targeted Safety	YES	5	15	No Inspector						Fall hazards throughout. Workers not tied off. Additional concrete contractor's safety personnel onsite, but ineffective
55	BKLYN	Y	1-Oct-08	Full	YES	4	15	No Inspector						Site Safety Improved since last visit
55	BKLYN	Y	13-Nov-08	Full	YES	4	15	YES						Sidewalk shed missing portion of overhead protection. Housekeeping. No reshore sequence. No formwork design drawings for multi-level formwork.
56	MNHTN	Y	13-Aug-08	Full	YES	UNK	32	No Inspector						Log of rebar inspection consisted of controlled inspectors initials on outdated set of shop drawings. Lack of reshore spacing specifications, reshores clustered in areas to allow localized work in "shore-free" areas. Many safety issues
56	MNHTN	Y	10-Sep-08	Targeted Safety	YES	UNK	32	YES						Workers not tied off at Building perimeter. Missing Vertical netting at floor levels 3 and 7. General poor site safety conditions.
56	MNHTN	Y	25-Sep-08	Targeted Safety	YES	5	32	YES						Site Safety personnel not able to mitigate safety issues. Unprotected edges. Handrails. Egress
56	MNHTN	Y	30-Sep-08	Targeted Safety	YES	5	32	No Inspector						Insufficient horizontal netting. Vertical netting now in compliance.

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56	MNHTN	Y	30-Sep-08	Targeted Safety	YES	5	32	YES						Vertical edge protection still not in compliance. Improper horizontal netting installation. Poor coordination.
56	MNHTN	Y	17-Oct-08	Targeted Safety	YES	5	32	YES						Unprotected edges throughout. Workers not tied off. Limited egress. Use of adjacent building for access. No safety coordination within project team.
56	MNHTN	Y	21-Oct-08	Targeted Safety	YES	3	32	No Inspector						GC slow to address safety issues. Lack of fall protection between buildings. Fall hazards at ladders to stripping floor.
56	MNHTN	Y	29-Oct-08	Targeted Safety	YES	5	32	YES						New Site Safety Manager on site, Not effective. Unprotected edges throughout. Horizontal netting not deployed. Workers not tied off. Housekeeping worse than before. Blocked egress.
56	MNHTN	Y	3-Nov-08	Targeted Safety	YES	5	32	YES						Site Safety Manager not effective. Exterior edges protected, interior edges not protected. Improvement in tie off compliance. Still poor housekeeping. Poor egress.
56	MNHTN	Y	13-Nov-08	Targeted Safety	YES	5	32	No Inspector						Site Safety Manager more effective. General safety improvement.
56	MNHTN	Y	18-Nov-08	Full	YES	3	32	YES						Illegible safety log. Workers not tied off. Insufficient edge protection between buildings. No reshore design. Concrete testing lab picked up cylinders late. No curing box.
56	MNHTN	Y	26-Nov-08	Targeted Safety	YES	5	32	NO						General improvement. However, workers still observed not properly tied off.

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57	MNHTN	Y	13-Aug-08	Full	YES	3	33	No Inspector						Lack of formwork drawings. Using adjacent building's formwork design. No vertical formwork specifications. No approved formwork drawings. Public and worker safety hazards, lack of fencing, construction barriers
57	MNHTN	Y	15-Sep-08	Full	YES	3	32	No Inspector						Unprotected interior floor openings
57	MNHTN	Y	15-Sep-08	Full	YES	3	32	NO						No Reshore sequence available
57	MNHTN	Y	25-Sep-08	Targeted Safety	YES	5	32	No Inspector						Site Safety personnel not effective in maintaining safety. Insufficient perimeter protections. Unprotected edges throughout site. Poor housekeeping
57	MNHTN	Y	30-Sep-08	Targeted Safety	YES	5	32	No Inspector						Site Safety Manager not effective. Unprotected edges. Netting not extended. Limited tie off compliance.
57	MNHTN	Y	17-Oct-08	Targeted Safety	YES	5	32	YES						Site Safety Manager not effective. Unprotected edges throughout. Workers not tied off. Flammable tires used as adjacent building protection. Obstructed egress. Overall hazardous site conditions.
57	MNHTN	Y	29-Oct-08	Targeted Safety	YES	5	32	NO						Site Safety Manager reacting to HRCO visits. Continued unprotected edges. Netting not fully extended. Tires on adjacent roof. Debris. Workers not tied off. BEST violation issuances needed.
57	MNHTN	Y	6-Nov-08	Targeted Safety	YES	5	32	YES						Improved exterior edge protection, interior edges still unprotected. Continued tie off noncompliance. Tie off violations not being enforced. Limited cooperation of project team

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57	MNHTN	Y	13-Nov-08	Targeted Safety	YES	5	32	No Inspector						Site Safety Manager increasingly effective, tie off compliance. Good perimeter protection
57	MNHTN	Y	28-Nov-08	Targeted Safety	YES	5	32	No Inspector						Major improvements. Good housekeeping, use of PFAS, fully-extended netting, Protected fall hazards throughout
58	MNHTN	Y	7-Nov-08	Full	YES	3	27	No Inspector						No Formwork inspection performed. Column ties and shear reinforcement not installed per plans. Special inspector not able to catch inconsistency. No reshore sequence available.
58	MNHTN	Y	22-Oct-08	Full	YES	3	27	YES						Missing railing. Housekeeping. Missing some shoring towers.
58	MNHTN	Y	24-Oct-08	Targeted Safety Reinspection	YES	3	27	NO						Violations lifted from previous visit
59	MNHTN	N	30-Sep-08	Full	NO	UNK (No Activity)	10	No Inspector						No Activity on Site
59	MNHTN	N	2-Oct-08	Full	YES	5	10	NO						No finalized stripping and reshoring sequence yet
60	MNHTN	Y	30-Sep-08	Full	YES	3	58	No Inspector						No Wall form inspections performed. Housekeeping and egress
60	MNHTN	Y	16-Oct-08	Targeted Safety	YES	UNK	58	No Inspector						
61	MNHTN	Y	11-Sep-08	-	NO	UNK	UNK	NO						No activity, empty lot
62	MNHTN	Y	30-Sep-08	Full	YES	3	20	No Inspector						No foundation wall inspection Log. No formwork inspection logs. Wall forms removed prior to knowledge of concrete strength
63	MNHTN	Y	15-Sep-08	Full	YES	UNK (Excavation)	13	NO						Improper concrete sampling. Concrete Inspector not ACI Level 1 certified.

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
64	MNHTN	Y	13-Aug-08	Full	YES	UNK	58	No Inspector						No stamped or perforated set of structural drawings. Public safety hazard, open gate with fall hazard into excavation. Fall hazards throughout. Protruding rebar.
65	MNHTN	NA	22-Sep-08	Targeted Safety	NO	UNK	UNK	NA						Demolition Site
66	MNHTN	NA	23-Sep-08	Not Active	NO	UNK	UNK	NO						No Activity
67	MNHTN	Y	8-Oct-08	Full	YES	2	44	NO						Lack of Egress. Horizontal netting not deployed fully. Multiple workers not tied off. Incorrect guardrail height. Cold bent splices in columns and shearwalls
67	MNHTN	Y	9-Oct-08	Targeted Engineering	YES	2	44	YES						Improper column splices and cold-bent embedded bars. Special inspector is PE, qualified but not effective (code violations present). Multiple unprotected edges. Worker not tied off placing ribs in formwork
68	MNHTN	Y	23-Sep-08	DOB requested visit for accident	YES	UNK	31	YES						Steel Building, concrete pump pipe burst. Partially-cured portions of incompletely poured composite slab.
69	MNHTN	N	24-Sep-08	Full	YES	UNK	14	YES						No Stamped formwork drawings. Contractor not performing Inspections. Worker not tied off. SWO in place presently due to adjacent building movement. Partially-embedded slab dowels bent. No Special Inspector logs. Slump not in conformance with mix design. Unprotected vertical netting opening
69	MNHTN	N	7-Nov-08	Full	YES	UNK	14	No Inspector						Unit weight and air test not performed per specifications. Air test uses chase meter instead of project-required pump test

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
70	BKLYN	Y	28-Aug-08	Full	NO	UNK	13	No Inspector						
71	BKLYN	Y	28-Aug-08	Full	NO	UNK	UNK	No Inspector						Stop Work Order In Place. No personnel on site.
72	MNHTN	Y	11-Sep-08	Full	YES	3	20	YES						Improper shore post spacing, no reshore specification. Engineer to issue note regarding formwork post spacing. Misplacement of rebar stirrups
72	MNHTN	Y	17-Sep-08	Reinspection	YES	3	20	NO						Corrected steel issues.
72	MNHTN	Y	17-Sep-08	Targeted Steel reinspection	YES	3	20	NO						Steel issues corrected
72	MNHTN	Y	23-Oct-08	Full	YES	3	20	NO						
72	MNHTN	Y	27-Oct-08	Full	YES	3	20	YES						Tie-off anchorages used on forming floor, pulled through holes in decking. Observed cold bent partially-embedded steel
73	MNHTN	N	23-Sep-08	Full	YES	3	9	NO						No horizontal formwork drawings available. Insufficient whaler size. Shop drawings without engineer's stamp
74	MNHTN	Y	29-Jul-08	Full	YES	2	16	No Inspector						
74	MNHTN	Y	25-Aug-08	Full	YES	2	16	NO						Three beams with congestion, lack of stirrup engagement and poor workmanship. Column with unhooked ties. Column and beams field fixed. Designers representatives onsite made field fix without EOR notification. Fix is suspect.
75	MNHTN	UNK	23-Sep-08	Targeted Safety	NO	UNK	UNK	No Inspector						No Activity
76	MNHTN	UNK	20-Oct-08	Full	YES	UNK (Below Grade)	58	YES						
77	MNHTN	N	11-Sep-08	Targeted safety	YES	5	11	YES						Limited use of fall protection.
77	MNHTN	N	17-Sep-08	Targeted safety	YES	5	11	YES						Adjacent property still not protected

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
77	MNHTN	N	23-Sep-08	Targeted safety	YES	5	11	No Inspector						Improved site conditions from last visit
77	MNHTN	N	17-Oct-08	Full	YES	3	11	No Inspector						No site safety log. Missing stair guardrail. Insufficient ladder length to upper deck. No special inspector reports. No approved shop drawings for this floor. Concrete sampling not in conformance with ASTM
78	MNHTN	Y	20-Oct-08	Full	NO	UNK (Excavation)	22	NO						Excavation
79	MNHTN	Y	22-Sep-08	Full	YES	3	38	NO						No form inspection logs. Improper fabrication of column ties
79	MNHTN	Y	10-Nov-08	Targeted Safety	YES	2	38	NO						
79	MNHTN	Y	12-Nov-08	Full	YES	2	38	NO						Improper use of air test equipment. Not in conformance with ASTM
80	MNHTN	Y	12-Aug-08	Full	YES	2	60	YES, Through EOC						2 day cycle, some safety and ACI violations observed, reported to Gus
81	MNHTN	Y	17-Sep-08	Full	Partially	3	67	NO						Excavation, but data recorded
82	MNHTN	Y	15-Sep-08	Full	Partially	UNK	60	NO						No formwork design available yet (still below grade) Site is idle
83	MNHTN	N	6-Oct-08	Full	YES	UNK (precast)	12	YES						Reinforcing engagement issues. Unhooked stirrup in grade beam. Controlled inspector not on site. No approved shop drawings stamped by EOR.
83	MNHTN	N	6-Oct-08	Full	YES	UNK (precast)	12	NO						Steel issues corrected
84	MNHTN	Y	24-Sep-08	Full	YES	4	45	NO						Some vertical netting missing, housekeeping issues. Limited form inspection logs, no vertical formwork design. No special inspection reports. Observed typical partially embedded bent column bars

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Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
84	MNHTN	Y	11-Sep-08	Full	YES	4	45	No Inspector						Incomplete formwork drawings, no reshoring sequence. Incomplete formwork drawings of upper floors
84	MNHTN	Y	16-Oct-08	Full	YES	3	45	YES						Improperly placed stirrups at 7th floor link beam. Also fresh concrete testing not in conformance with ASTM requirements. Observed prior to BEST arrival, no violation issued
84	MNHTN	Y	21-Oct-08	Full	YES	3	45	NO						Safety improvements since last visit.
84	MNHTN	Y	30-Oct-08	Targeted Safety	YES	4	45	YES						Unprotected fall hazards. Horizontal netting not extended. Most workers not tied off. Housekeeping inadequate. Improperly constructed work platform, no bracing. Material stored on platform w/o bracing
84	MNHTN	Y	5-Nov-08	Targeted Safety	YES	4	45	No Inspector						Improvement in most areas. However, most workers not using PFAS
84	MNHTN	Y	10-Nov-08	Targeted Safety	YES	4	45	YES						Major lack of tie-off compliance. This is a recurring issue. Other safety aspects are adequate
84	MNHTN	Y	20-Nov-08	Full	YES	3	45	No Inspector						Embedded lanyards not installed. Horizontal netting not fully deployed. Vertical netting not tied down. Non-Conforming lap column splices >6". Splicing issues identified last visit, not resolved.
84	MNHTN	Y	20-Nov-08	Targeted Safety	YES	4	45	NO						Improved Tie-off compliance
84	MNHTN	Y	28-Nov-08	Targeted Safety	YES	4	45	No Inspector						Workers generally using PFAS. One worker not tied off
84	MNHTN	Y	26-Nov-09	Targeted safety	YES	4	45	No Inspector						Missing guardrails at hoist

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
85	BKLYN	Y	18-Aug-08	Full	YES	5	33	YES						No reshore sequence available, contractors experience only. Hard hat violations. Per contractor engineer gives approval prior to stripping floors. Poor chain of command between Site Safety Manager and trades. Lack of respect B/W trades and safety manager. Site Safety Manager unable to control project, under pressure to keep low profile
85	BKLYN	Y	28-Aug-08	Targeted Engineering	YES	5	33	No Inspector						Field Modification and RFI log kept on site. Verbal or written approvals needed for execution of Field Modifications. Observed some misplacement, brought to attention of PEO
85	BKLYN	Y	3-Sep-08	Full	YES	5	33	YES						Column ties and stirrups not properly engaged at multiple locations. Unstable timber posts between shoring tower and slab. Worker standing on ladder top, not tied off. Unprotected west elevation. Site Safety Manager not effective
85	BKLYN	Y	10-Sep-08	Targeted Safety and Engineering Steel	YES	5	33	YES						Observed additional steel issues, improper leg lengths, stirrups not engaged to beam bottom steel in transfer girder, 135 u-stirrup ends cut off. Multiple workers observed not tied off. Shear wall steel ties not hooked
85	BKLYN	Y	18-Sep-08	Targeted Steel reinspection	YES	5	33	NO						New Lather Crew and new Special Inspector. Improved Housekeeping from last visit. Shearwall ties not engaged

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Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
85	BKLYN	Y	23-Oct-08	DOB Process	NO	5	33	NA		NA	NA	NA	NA	Visit to Boro office confirms city is missing full set of up-to-date construction documents. Missing Arch/mech/civil/Foundation, and portions of Structural drawings. No perforated set on file in hard copy or microfilm. Documents either misfiled or full set of drawings never submitted.
85	BKLYN	Y	23-Oct-08	Targeted Safety	YES	5	33	YES						Safety personnel unable to identify or fix safety issues. Workers not tied off. Missing vertical netting on each floor. Inconsistent testing practices, not ASTM standard concrete testing.
85	BKLYN	Y	23-Oct-08	Targeted Safety	YES	5	33	NO						Site Safety Manager ineffective. Unprotected edges throughout. Most workers not tied off. Housekeeping. No safety coordination or enforcement within project team. Material storage
85	BKLYN	Y	30-Oct-08	Targeted Safety	YES	5	33	YES						Site Safety Personnel still not effective. Exposed unprotected edges. No tie off enforcement. Obstructed egress. No general improvement in site safety. Improper wood post installation at scaffold tower
85	BKLYN	Y	3-Nov-08	Targeted Safety	YES	5	33	YES						Site Safety Manager not effective. Unprotected edges. Workers not tied off. Obstructed exits. Materials stored at building edge. Improper shore installation (timber on end, this is a recurring problem at this site). Project Manager and Site Safety personnel have no effective methods to provide safe working conditions

NYC Department of Buildings - High Risk Construction Oversight (HRCO)

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
85	BKLYN	Y	5-Nov-08	Targeted Safety	YES	5	33	No Inspector						SS Personnel have no control over site safety. Still inadequate edge protection, but installing. No tie off compliance. Blocked egress. 3rd floor Partial SWO still in effect. Project team is not making safety a priority.
85	BKLYN	Y	7-Nov-08	Targeted Safety	YES	5	33	No Inspector						SS personnel effectiveness improved. Beginning installation of more vertical netting. Most workers without tie off . Partial SWO still in effect for 3rd floor
85	BKLYN	Y	12-Nov-08	Targeted Safety	YES	5	33	No Inspector						SS Issues beginning to improve. Need 3rd floor setback protection. Some worker still not tied off, but improved. Most edges now protected
85	BKLYN	Y	14-Nov-08	Targeted Safety	YES	5	33	No Inspector						Improved SS Personnel effectiveness. Adequate vertical netting. Still no overhead protection at 3rd floor. Workers observed in violation of 3rd floor Partial SWO. Other SS conditions improved
85	BKLYN	Y	24-Nov-08	Targeted Safety	YES	5	33	No Inspector						SS Personnel still not effective. Inadequate vertical netting. Unprotected interior openings. Workers not tied off. Requested Revisit with BEST
85	BKLYN	Y	25-Nov-08	Targeted Safety	YES	5	33	YES						Site Safety Manager ineffective. Missing edge protection. Many workers not tied off
85	BKLYN	Y	28-Nov-08	Targeted Safety	YES	UNK	33	NO						Inadequate SS Logs. Adjacent building protection noncompliance.
86	MNHTN	Y	28-Aug-08	Targeted Safety	YES	UNK	30	No Inspector						

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
87	MNHTN	Y	14-Aug-08	Full	YES	4	76	No Inspector						Timber on ends of towers. Missing Perimeter Edge protection. Formwork Workmanship unstable. Missing Reshoring Sequence. No formwork inspection logs. Lateral shore bracing not in conformance with design. Unprotected edges on sixth floor
87	MNHTN	Y	5-Sep-08	Targeted Safety	YES	4	76	YES						Two Unprotected areas without vertical netting. Egress path unclear. Incomplete site safety log. Engineer not following stripping procedure outlined in project specifications.
87	MNHTN	Y	5-Sep-08	Full	YES	4	76	YES						Per engineer, project specification requirements for form stripping are not applicable and are to be revised. Workers not tied off in elevator shaft, no edge protection on forming floor. Premature form stripping
87	MNHTN	Y	10-Sep-08	Targeted Safety	YES	3	76	No Inspector						
87	MNHTN	Y	15-Oct-08	Full	YES	3	76	No Inspector						Workers not tied off. Premature lateral bracing removal. No knowledge of concrete strength prior to stripping. Concrete tests not performed per ASTM
87	MNHTN	Y	14-Nov-08	Full	YES	3	76	NO						Missing railings on stairs. Insufficient use of hard hats. No concrete inspector onsite during stair pour.
88	MNHTN	Y	13-Aug-08	Full	YES	5	43	YES						Observed removal of PERI system lateral braces immediately below active casting floor. Design calls for reshoring at 14 days. Unsafe stacked stringer installation. Unused lateral braces. Peri Tower height exceeds design

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
88	MNHTN	Y	28-Aug-08	Targeted Engineering	YES	5	43	YES						Observed improperly installed additional top steel at interior columns and improperly installed additional top steel at exterior wall. Controlled inspector stated he left the site before rebar placement was complete. Lateral bracing for shoring directly below pouring floor was removed in the Northeast corner. GC requested bracing be reinstalled.
88	MNHTN	Y	30-Sep-08	Targeted Safety	YES	UNK	43	No Inspector						
89	MNHTN	Y	27-Aug-08	Targeted Safety	YES	UNK	15	No Inspector						Workers Not tied off on Forming Level
90	MNHTN	Y	27-Aug-08	Targeted Safety	YES	UNK	34	No Inspector						Limited ability of Site Safety Manager to maintain control of site. Housekeeping violations and unprotected edge violations previously issued by BEST.
90	MNHTN	Y	4-Sep-08	Full	NO	UNK	30	NO						Insufficient egress at casting floor. Formwork removal premature, not in conformance with specifications. No reshoring sequence or number of floors specified
91	MNHTN	Y	21-Aug-08	Full	YES	UNK	53	No Inspector						No Cracking Specification. No logs of formwork inspection. Improper column splice installation. Per engineer, dowels to be drilled and epoxied for proper splicing. Workers not tied off installing formwork ribs. Improper cutting of stirrup hooks

Unique Identifier No.	Boro	Major Building	Visit Date	Visit Type	Active?	Floor Cycle Time (days)	Proposed Stories	Violations Issued	Housekeeping Violations	Unprotected Edge Violations	Tie-off Violations	Formwork Non Compliance Violations	Construction Quality Violations	Notes
91	MNHTN	Y	30-Sep-08	Full	YES	4	53	No Inspector						No Formwork inspection logs. Workers not appropriately tied off, housekeeping, cannot keep up with stripping floor operations. No egress from working deck. Deck concrete hosed down for workability. No stripping sequences available. Sequencing not specified in design. Uncontained material storage.
92	MNHTN	Y	12-Nov-08	Full	YES	4	52	No Inspector						Netting not secured at bottom. Housekeeping on stripping floor. Improper post tie-offs at edge
93	MNHTN	Y	30-Sep-08	Full	NO	UNK (Excavation)	48	No Inspector						
94	MNHTN	UNK	22-Sep-08	Full	NO	UNK	0	No Inspector						Site Closed due to previous SWO, failure to protect public and property

Appendix B.2: Comparative Concrete Testing

A preliminary audit of concrete property reporting was performed by the HRCO. Comparisons were made between results provided by the labs in question with results provided by an independent laboratory (The Port Authority of New York and New Jersey). The following assessments of five labs (designated A through E) were made by HRCO staff, and included some facilities visited during the Laboratory Quality assessment.

TESTING LAB: A

SITES: Site 87, 15-October 2008

Site 72, 12-November 2008

The following report provides comments regarding the sites sampled by the HRCO and Test Well on the date and site noted above.

Testing Methods

In accordance with ASTM C94 “Standard Specification for Ready-Mixed Concrete” concrete should be tested for unit weight and air content in conformance with ASTM C138 “Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete” and ASTM C231 “Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method” respectively.

During the field sampling performed by this lab, it was observed that neither ASTM compliant unit weight testing, nor any surrogate unit weight test method was performed. Air testing was performed using the chase air indicator which is not an ASTM standard, and as noted by the manufacturer of the product, does not qualify as a substitute for the pressure or volumetric method prescribed by ASTM. Test reports do not indicate the test methods by which air content and unit weight were obtained, although the report suggests full ASTM conformance by making reference to ASTM C94.

Reporting Of Test Results

Compressive strength test results, as prescribed by ASTM C39 “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens”, should be reported at the age of 24 hours, 3 days, 7 days, 28 days, and 90 days within their respective tolerances unless otherwise required in the project specifications. Compressive strength test results of individual cylinders reported for both sites do not comply with the age requirements set forth in ASTM C39. In the case of Site 87, samples prepared on 15-Oct. 2008, were tested at an age of 37 days, and no testing was performed at 28 days. The Site 72 samples prepared on 12-Nov. 2008 were tested at 10 days, 29 days and 37 days. There is a possibility that the 29 day test result is within tolerance, although the time of day at which the samples were prepared and tested is not provided.

Lab test reports indicate fracture pattern type 5. This fracture pattern is typically found in tests performed with un-bonded caps. When this type of fracture occurs during testing, ASTM C39 recommends continuing compressing the specimen until a different fracture is achieved. Therefore, these results further suggest this lab's non-conformance with ASTM standards.

Test Results

The following table presents the test results for the sites sampled by the HRCO and Lab A. Test results were extracted from reports provided by the Department of Buildings' independent laboratory, The Port Authority of New York and New Jersey.

Table 1. Summary of Concrete Compressive Strength Results at Site 87

Site Location (date)	Testing Agency	ID	Air (%)	UW (lbs/cuft)	Specified strength (psi)	Age (days)	Average f'c (psi)	% based on 28 day strength
Site 87 (10/15/2008)	Port Authority	Site 87	1.6	152.8	9000	6	7450	70
						28	10665	100
	Lab A	set 3	2.2	152		7	7630	NA
						37	11060	NA
						56	11105	NA
		set 5	2.0	151		7	8270	NA
						37	11940	NA
						56	11990	NA
		set 8	2.2	152		7	8370	NA
						37	11460	NA
						56	12190	NA

Table 2. Summary of Concrete Compressive Strength Results at Site 72

Site Location (date)	Testing Agency	ID	Air (%)	UW (lbs/cuft)	Specified strength (psi)	Age (days)	Average f'c (psi)	% based on 28 day strength
Site 72 (10/27/2008)	Port Authority	Site 72	5	148.8	5000	7	4800	75
						28	6370	100
	Lab A	set 1	3	149		10	4850	NA
						29	5280	100
						37	5440	NA

General Comments:

- Strength development rends are typical
- The Site 87 strength test results for specimens at 6 and 7 days, are similar for both testing agencies.
- At Site 72, strength development rate of the concrete specimens appears lower than those sampled by HRCO engineers. The rate at which concrete develops strength is related to the mix proportions, curing time and curing temperature.

TESTING LAB: B

SITES: Site 56, 21-October 2008

Site 41, 23-October 2008

Site 14, 5-November 2008

The following report provides comments regarding the sites sampled by the HRCO and Laboratory B on the date and site noted above.

Testing Methods

In accordance with ASTM C94 “Standard Specification for Ready-Mixed Concrete” concrete should be tested for unit weight and air content in conformance with ASTM C138 “Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete” and ASTM C231 “Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method” respectively.

HRCO engineers were present at three sites where this lab generated an “Inspection and Testing of Concrete Report” which summarized information related to the concrete placement on a specific date and the strength of the corresponding specimens. HRCO engineers observed test methods utilized by this lab during their sampling of fresh concrete properties, and observed they failed to perform unit weight testing. Furthermore, air content testing was performed using the chase air indicator, which is not an ASTM standard and, does not qualify as a substitute for the pressure or volumetric method prescribed by ASTM.

Lab test reports produced by lab B do not indicate the test methods by which air content and unit weight were obtained, or if test methods were performed in accordance to the standards recommended by ASTM C94.

Reporting Of Test Results

Compressive strength test results should be reported in accordance with ASTM C 39 “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens”. The standard indicates that the fracture pattern produced by compressive testing should be included in the test report. The reports produced by this lab indicate the fracture pattern for *all* cylinders, even those not subjected to compressive testing, is type “A”, suggesting this classification is a “default” pattern on the spreadsheet used to generate the report. Reporting in this manner raises concerns regarding the accuracy of lab B’s test reporting.

Test Results

The following table presents the test results for the sites sampled by HRCO engineers and Lab B. Test results were extracted from reports provided by the Department of Buildings' independent laboratory, The Port Authority of New York and New Jersey.

Table 1. Summary of Concrete Compressive Strength Results at Site 56

Site Location (date)	Testing Agency	ID	air (%)	UW (lbs/cuft)	Specified strength (psi)	Age (days)	f'c(psi)	% based on 28 day strength
Site 56 (10/21/2008)	Port Authority	[redacted]	1.0	146	5950	2	2650	43
						7	4355	71
						14	4820	79
						28	6120	100
	Lab B	52AS	3.0	146		7	4685	77
						28	6117	100
		52BS	3.5	146		7	4415	74
						28	5963	100

Table 2. Summary of Concrete Compressive Strength Results at Site 41

Site Location (date)	Testing Agency	ID	air (%)	UW (lbs/cu ft)	Specified strength (psi)	Age (days)	f'c(psi)	% based on 28 day strength
Site 41 (10/23/2008)	Port Authority	[redacted]	1.5	150	5000	7	4570	74
						28	6176	100
	Lab B	1S	3.0	153		7	4980	80
						29	6250	100
		2S	2.4	155		7	4790	79
						28	6043	100
		3	2.7	153		7	4920	76
						28	6453	100

Table 3. Summary of Concrete Compressive Strength Results at Site 14

Site Location (date)	Testing Agency	ID	air (%)	UW (lbs/cuft)	Specified strength (psi)	Age (days)	f'c(psi)	% based on 28 day strength
Site 14 (11/5/2008)	Port Authority	[redacted]	3.3	152	8000	2	6510	NA
						7	8420	NA
						28	[redacted]	NA
	Lab B	10S	1.9	150		7	9690	81
						14	10780	91
						28	11910	100
		11S	1.5	153		7	8580	75
						14	9830	86
						28	11400	100

General Comments:

- Trends in strength development and strength levels are similar for both testing agencies

TESTING LAB: C

SITE: Site 16, Manhattan 29-October, 2008.

The following report provides comments regarding the sites sampled by the HRCO and Laboratory C on the date noted above.

Testing Methods

In accordance with ASTM C94 “Standard Specification for Ready-Mixed Concrete” concrete should be tested in for unit weight and air in conformance to ASTM 138 “Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete” and ASTM 231 “Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method” respectively.

During the field sampling performed by HRCO engineers at Site 16, it was observed that laboratory staff did not perform ASTM compliant unit weight or air content testing. Test reports do not indicate the test methods by which air content and unit weight were obtained and reported.

Reporting of Test Results

Compressive strength test results should be reported in accordance with ASTM C 39 “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens”. Strength test results reported by this lab do not list the type of fracture pattern as prescribed by ASTM C39. This particular item is of importance because cylinders tested with unbonded caps are likely to exhibit varying fracture patterns, and an analysis of these patterns by the engineer may indicate if the cylinder’s ultimate strength has been appropriately reported.

ASTM C39 also requires that specimen size, loaded area of cylinder, and load levels be reported on standard laboratory reports. Test reports provided by lab C failed to provide this information.

Test Results

The following table presents the test results for the site sampled by HRCO engineers and Laboratory C. Test results were extracted from reports provided by the Department of Buildings’ independent laboratory, The Port Authority of New York and New Jersey.

Table 1. Summary of Concrete Compressive Strength Results at Site 16

Site Location (date)	Testing Agency	Field ID	Lab ID	air (%)	UW (lbs/cuft)	Age (days)	f'c (psi)	% based on 28 day strength
Site 16 (10/29/2008)	Port Authority	[redacted]	[redacted]	8.0	140	2	3170	58
						7	3810	70
						28	5435	100
	Lab C	175	1819-1822	4.0	141	7	3970	75
						28	5260	100
		178	1830-1833	4.5	145	7	4490	69
						28	6490	100
		180	1838-1840	4.5	144	28	6010	100

General comments:

- Trends of the concrete strength development appear similar for testing performed by both laboratories

TESTING LAB: D

SITES: Site 67, 10-October 2008

Site 4, 15-October 2008

Site 79, 12-November 2008

The following report provides comments regarding laboratory D test sites observed by the HRCO on the dates noted above.

Testing Methods

Reports prepared by Lab D indicate that unit weight and air content testing should be performed in accordance to ASTM C138 “Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete”, and ASTM C231 “Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method” respectively. During the field sampling performed by HRCO engineers at these sites, it was observed that Lab D did not perform any ASTM-compliant unit weight testing. Furthermore, air content testing was performed using the chase air indicator, which is not an ASTM standard, and does not qualify as a substitute for the pressure or volumetric method prescribed by ASTM.

Reporting Of Test Results

Compressive strength test results, including fracture pattern, must be reported in accordance with ASTM C39 “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens”. Strength test results reported by this laboratory do not list the type of fracture pattern as prescribed by ASTM C39. This particular item is of importance because cylinders tested with un-bonded caps are likely to exhibit varying fracture patterns, and an analysis of these patterns by the engineer may indicate if the cylinder’s ultimate strength has been appropriately reported.

Test Results

The following table presents the test results for the sites sampled by HRCO engineers and laboratory D. Test results were extracted from reports provided by the Department of Buildings’ independent laboratory, The Port Authority of New York and New Jersey

Table 1. Summary of Compressive Strength Test Results at Site 67

Site Location (date)	Testing Agency	Specified strength (psi)	ID	Air (%)	Unit Weight (lbs/cuft)	Age (days)	Average f'c (psi)	Percentage of 28 day f'c
Site 67 (10/10/2008)	Port Authority	7000	Site 67	2.8	149.6	2	4350	42
						7	7395	72
						28	10325	100
	Lab D		3250E	2.5	149.9	7	8490	82
						28	10417	100
			3250B	2.25	149.9	7	8435	86
						28	9830	100
			3250G	2.0	149.9	7	7980	85
						28	9440	100

Table 2. Summary of Compressive Strength Test Results at Site 4

Site Location (date)	Testing Agency	Specified strength (psi)	ID	Air (%)	Unit Weight (lbs/cuft)	Age (days)	Average f'c (psi)	Percentage of 28 day f'c
Site 4 (10/15/2008)	Port Authority	8300	Site 4	1.6	149.6	6	8630	67
						28	12970	100
	Lab D		3304A	2.0	149.9	7	6360	73
						28	8703	100
			3304B	2.25	149.9	7	6480	75
						28	8640	100
			3304C	2.5	149.9	7	6230	75
						28	8340	100

Table 3. Summary of Compressive Strength Test Results at Site 79

Site Location (date)	Testing Agency	Specified strength (psi)	ID	Air (%)	Unit Weight (lbs/cuft)	Age (days)	Average f'c (psi)	Percentage of 28 day f'c
Site 79 (11/12/2008)	Port Authority	9000	Site 79	4.1	148.0	2	5220	NA
						7	10220	NA
						28	[redacted]	NA
	Lab D		3498	2.0	154.3	1	3580	NA
						7	7590	NA
						28	[redacted]	NA

- Port Authority and laboratory D strength test results exhibit similar trends and strength development

- Average compressive strength results provided by this lab, corresponding to sites 79 and 4, were consistently lower than those tested by the Port Authority. The approximate difference in average strength at 28 days was 35%.

- Strength levels, based on a percentage of the 28 day strength, were generally 10% lower for the results reported by lab D when compared to the data provided by the Port Authority.

TESTING LAB: E

SITE: Site 85, 23-October 2008

The following report provides comments regarding the sites visited by the HRCO and Laboratory E on the dates noted above. HRCO did not sample concrete from this site, but specimens from which strength results were obtained were provided to the HRCO by lab E and the Department of Buildings' independent laboratory, The Port Authority of New York and New Jersey.

Testing Methods

ASTM C94 "Standard Specification for Ready-Mixed Concrete" dictates proper test procedures for concrete testing. According to ASTM C94, unit weight and air content testing should be performed in conformance to ASTM C138 "Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete" and ASTM C231 "Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method" respectively. At this site, lab E did not perform any ASTM-compliant unit weight testing. Furthermore, air content testing was performed using the chase air indicator, which is not an ASTM standard, and does not qualify as a substitute for the pressure or volumetric method prescribed by ASTM.

Lab test reports produced by this lab do not indicate the tests methods by which air content and unit weight were obtained, or if test methods were performed in accordance to the standards recommended by ASTM C94.

Reporting Of Test Results

Compressive strength test results should be reported in accordance with ASTM C 39 "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens". Strength test results reported by ASC do not list the type of fracture pattern as prescribed by ASTM C39. This particular item is of importance because the analysis of the fracture pattern by the engineer may indicate if the cylinder's ultimate strength has been appropriately reported.

Comparison of Test Results

Laboratory E reported on 23-October 2008, that twenty-five (25) 4"x8" cylinders were set aside for the HRCO including fourteen (14) cylinders specified at 7000 psi, and eleven (11) cylinders specified at 9000 psi.

Upon returning to the site, the HRCO found only three of the reported eleven 4"x8" 9000 psi cylinders. Table 1 compares the results of concrete testing as reported by lab E and the HRCO's independent laboratory. The compressive strength results provided by this lab are not consistent with cylinder dimensions reported in the field. Data suggests lab E either failed to accurately field-report cylinder dimensions, or fabricated compressive strength data for nonexistent cylinders. It is unknown if lab E possesses the equipment necessary to load a specimen to 360 kips.

Table 1. Reported Cylinder Properties

Reporting Laboratory	Test Age (Days)	Reported Dimensions of Cylinder (in.x in.)	Area (in^2)	Load (lbs)	Strength (psi)
Lab E*	28	6x12**	28.27	360000	12730
HRCO	28	4x8	12.57	156600	12460

***Data obtained from laboratory report dated 23-October 2008-Specimen 81G**

****Cylinder size contrary to that documented in field report**

Test Results

The following table presents the test results for the sites sampled by lab E, and provided to the HRCO. Test results were extracted from reports provided to the Department of Buildings.

Table 2. Summary of Concrete Compressive Strength at Site 85

Site Location (date)	**Testing Agency**	**ID**	**air (%)**	**UW (lbs/cuft)**	**Specified strength (psi)**	**Age (days)**	**f'c (psi)**	**% based on 28 f'c**
Site 85 (10/23/2008)	Port Authority	N/A	N/A	N/A	7000 psi	7	6330	80
						28	7885	100
	Lab E	79	5.0	147		1	3890	[redacted]
						7	6760	[redacted]
		80	5.5	147		1	4320	[redacted]
						7	6530	[redacted]
	Port Authority	N/A	N/A	N/A	9000 psi	7	9410	78
						28	12070	100
	Lab E	81	2.0	153		1	4780	38
						7	10390	82
						28	12637	100
		82	1.0	153		1	4780	41
						7	10100	86
						28	11745	100

General Comments:

- Compressive strength development and results appear similar for both testing agencies.

Appendix B.3: Laboratory Quality Observations

After assessing the testing procedures and results from a number of concrete testing laboratories, the HRCO team concluded that laboratory quality varies greatly and that continued monitoring of the laboratory's ability to perform ASTM-compliant testing is well warranted. The following observations of three labs (designated D, E, and F) were made by HRCO staff in January 2008.

Testing Lab D

The following observations were compiled during an HRCO team visit to Testing Laboratory D conducted on January 22, 2008:

- Lab employs at least three ACI certified strength testing technicians
- Observed organized curing room and laboratory record-keeping.
- Lab utilizes automated testing equipment for application of load.
- Insufficient record keeping in regards to reusable neoprene caps.
- Test results fail to record compression failure mode. Lack of notation not in conformance with ASTM C31.

Testing Lab E

The following observations were compiled during an HRCO team visit to Testing Laboratory E conducted on January 22, 2008:

- Cylinder de-molding occurred four days after delivery, timing not in conformance with specifications of ASTM C31.
- Cylinders only partially immersed in water, not in conformance with specifications of ASTM C31 (Figure B.3.1).
- Lack of proper water circulation in curing trough. Temperature of water in trough is 10° higher than allowed by ASTM C31.
- Lack of certified personnel (ACI strength testing technician)
- Compression equipment not automated, technician must indirectly control loading rate.
- Lack of humidity sensor in curing room.
- Insufficient equipment available to properly measure core or cylinder dimensions.
- Final reports lack reference to testing methods or ASTM standards.

- Test results fail to record compression failure mode. Lack of notation not in conformance with ASTM C31.

Figure 1: Improper Cylinder Curing Procedures, Some Cylinders Partially Immersed

Testing Lab F

The following observations were compiled during an HRCO team visit to Testing Laboratory F conducted on January 21, 2008:

- No ACI certified strength testing technicians present during visit.
- Curing room appeared to contain adequate temperature and moisture conditions and controls.
- Cylinder storage not organized, cylinders stacked on top of each other.
- Records indicate that testing machines were recently calibrated, however, the loading system is not automated, and the rate of loading must be controlled manually.
- Unbonded neoprene cap records indicate some caps were used more than One hundred times, exceeding provisions of ASTM C1231 / C1231M – 09: *Standard Practice for Use of Un-bonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders*.

Test results fail to record compression failure mode. Lack of notation not in conformance with ASTM C31.

C. Cranes and Hoists

C.1 INTRODUCTION

This chapter summarizes the crane and hoist assessment, and includes this introduction (Section 1), aspects of crane safety (Section 2), observations completed during assessment period (Sections 3), DOB process review and industry outreach (Section 4) and a summary of the recommendations (Section 5). Crane Tech Solutions and Patuxent Engineering Group principally authored the crane and hoist sections of this chapter, respectively.

The overriding themes of these recommendations are the importance of knowledgeable and experienced workers (both industry and regulatory), promotion of oversight and modernization of equipment.

From all sources available to the HRCO: historical studies; meetings with industry, manufacturers and DOB; and, our own experience, the most important factor for safe crane operations is having knowledgeable and experienced workforce. Recommendations for crane erection, climbing and disassembly, third party inspections, maintenance & repair all serve to increase the level of knowledge and experience available to the crane workforce during critical operations.

Promotion of oversight seeks to make DOB more efficient in its role. Recommendations such as Tracking Mobile Cranes (to improve the ability of DOB to observe these machines), Third Party Inspections (which remove the day-to-day resource obligations for inspections from DOB) and Maintenance & Repair (which allows tracking of critical crane repairs) all streamline DOB’s ability to enforce regulations. Many of the issues identified by the HRCO are already addressed by existing regulations; what is needed is the ability to efficiently enforce the regulations and identify the minority of individuals and companies that are habitually out of conformance.

Modernization of equipment will provide many benefits. In general the recommendations do not specifically call for changes in equipment, but many of the issues addressed by the recommendations would be improved with a newer fleet. For example, a number of marginal rigging practices, such as those associated with “riding a load” (in which a worker must stand on a piece of equipment while it is being lifted), would be obviated by employing newer tower cranes.

These themes are reflected in recommendations regarding Crane & Derricks Unit (C&D) operations, and in many ways have already been taken up by C&D following a recent restructuring. For example, C&D is working to enhance staff training in many ways including additional hands-on training for field inspectors and exposing plan examiners to field inspections. Also, C&D has been working to improve and streamline its approach to oversight with initiatives such as formalizing Standard Operating Procedures and development of a database that will ultimately be accessible by the public.

In additional to assessing crane operations, the HRCO team identified a gap in regulation of hoist equipment in NYC. There is potential for significant accidents and injuries associated with these machines. Therefore the HRCO included assessments of hoist machines as a subset of the crane study.

C.2 Aspects of Crane Safety

Accident Causes

Crane safety is an important component of overall construction safety. The Occupational Safety and Health Administration (OSHA) compiles national data on both general construction and crane-specific accidents. Studies of the OSHA data identify crane accidents to be associated with 8%[1] to 16.1%[2] of construction fatalities.

The variation is not surprising; as important as crane operations are, the available national crane accident data is far from complete. In the first place, many crane accidents go unreported. For those that are investigated by a regulatory authority, there is no consistent, master database of crane accident records across the country. For the most part, studies of historical data require in-depth review of actual accident reports to identify causal factors. Numerous studies of OSHA data have endeavored to identify leading factors that cause accidents, some of the most notable lists of accident causes are summarized in Table C.1.1.

Center to Protect Worker's Rights (CPWR)[3] Source: Selected OSHA records for 1984 - 1994		Sheppard et. al. (2000)[4] Source: Selected OSHA records for 1984 - 1994		Construction Industry Research and Policy Center (CIRPC)[1] Source: OSHA Records for 1997-2003	
Cause	Percent	Cause	Percent	Cause	Percent
Electrocution	39%	Electrocution	36%	Struck by load	32%
Assembly/Dismantling	12%	Fall of load	10%	Electrocution	27%
Boom Buckling	8%	Overturn	7%	Assembly/disassembly	12%
Upset/overturn	7%	Dismantling	6%	Failure of boom/cable	12%
Rigging	7%	Caught b/n counterweight	3%	Tip over	11%
Other	27%	Other	38%	Struck by cab/counterweight	3%
				Falls	2%

Table C.1.1: Summary of Crane Accident Study Findings

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[1] Beavers, J.E. et.al., Crane-Related Fatalities in the Construction Industry, *University of Tennessee Construction Industry Research and Policy Center (CIRPC)*, March, 2005.

[2] Neitzel, R.L., et.al., A Review of Crane Safety in The Construction Industry, *Applied Occupational and Environmental Hygiene* 16(12), 2001.

[3] McCann, M., et.al., Crane-Related Deaths in Construction and Recommendations for Their Prevention, The Center for Construction Research and Training (CPWR).

[4] Shepard, G.W., et.al., Crane Fatalities – A Taxonomic Analysis, *Safety Science* 36(2), 2000.

Similarly, a 2009 study from the Technion-Israel Institute of Technology is a first step in an attempt to determine, with greater accuracy, factors that influence crane safety. This first phase of the study involved a detailed survey of crane experts. Twenty one primary factors that effect crane safety were identified and weighted.

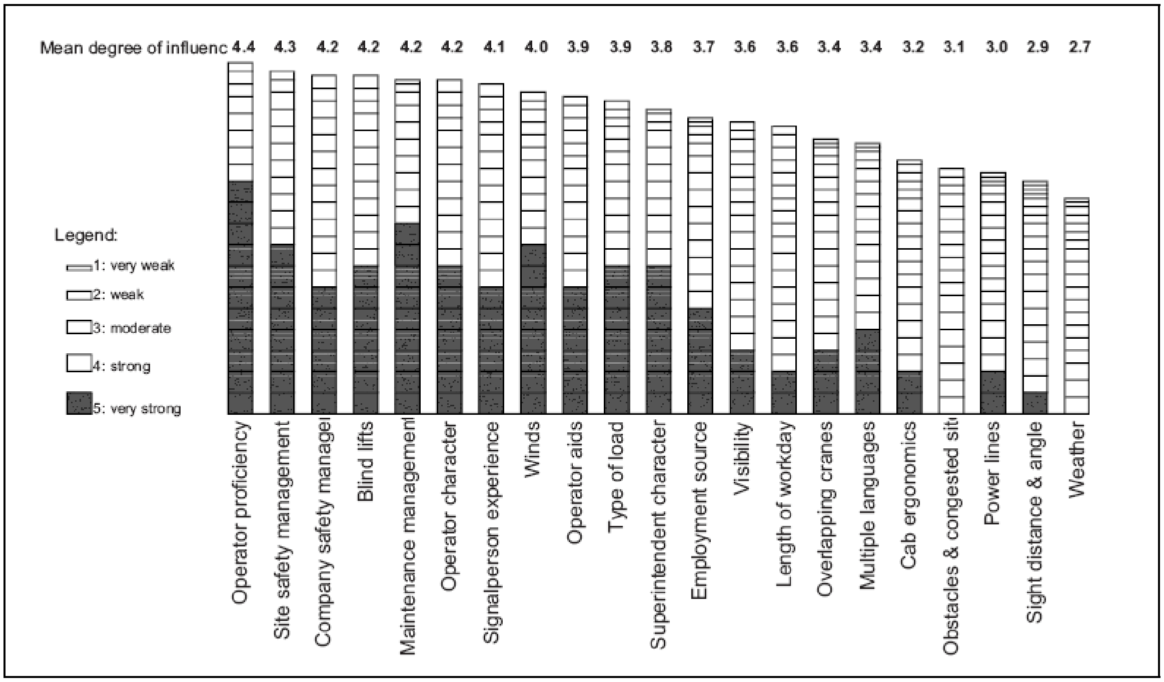


Figure C.1.1: Weighting of Factors that Affect Crane Safety.

These factors have varying degrees of relevance to the New York crane environment. The most significant point being that the study of causes of crane accidents is still in its infancy and that there are a wide range of factors that cause accidents. There is only a general understanding of leading causes, and little clear guidance on factors and practices that would best reduce accidents. Perhaps the most common theme is the role of human error in a majority of accidents and the related importance of worker knowledge and experience to avoid failures.

Consequence and Impact

What will be termed *high-consequence* crane accidents are of particular concern for the HRCO study. High-consequence crane accidents are generally associated with tower and large mobile cranes, and are qualitatively differentiated as having a high potential for multiple fatalities (including bystanders) and significant destruction of property.

Based on HRCO analysis of historic NYC accident data, between January 2006 and December 2008, 75% of fatalities and 55% of injuries were associated with just three major tower crane failures (Table C.1.2). One failure in particular (March 15, 2009 51st failure) accounted for 58% and 42% of fatalities and injuries, respectively.

Date	**Description**	**Injuries**	**Fatalities**
Sept. 29, 2006	Tower crane failure during dismantling.	5	0
March 15, 2008	Tower crane collapse.	22	7
May 30, 2008	Tower crane collapse.	2	2
Totals for high-consequence (% of all causes)	3 accidents (13%)	29 (56%)	9 (75%)
Total all causes	23 accidents	52	12

Table C.1.2: NYC Crane injuries and fatalities for three year period, January 2006 – December 2008.

The high-consequence of accidents involving tower and large mobile cranes is a function of the size of the machines and magnitude of load that they are capable of lifting. Typical tower and large mobile cranes have impact diameters of hundreds of feet (based on the height and reach of the cranes). The equipment itself typically weighs tens of thousands of pounds and is capable of lifting hundreds of thousands of pounds.

Figure C.1.2 shows an impact zone with a 200 foot radius. Within this zone are dozens of buildings and on the order of 1,000 people. The hypothetical impact zone is shown for an actual past crane location, and one at which there was a significant failure during dismantling of the crane.

As is the nature of most high-consequence events, the probability of major crane accidents is low. Along with low probability of occurrence, there is also a low probability of repetition of cause. The HRCO is not aware of any authoritative set of data of high-consequence crane failures. An informal list compiled by the HRCO identified that after assembly, climbing and dismantling; there was little repeatability in the source of the accidents.

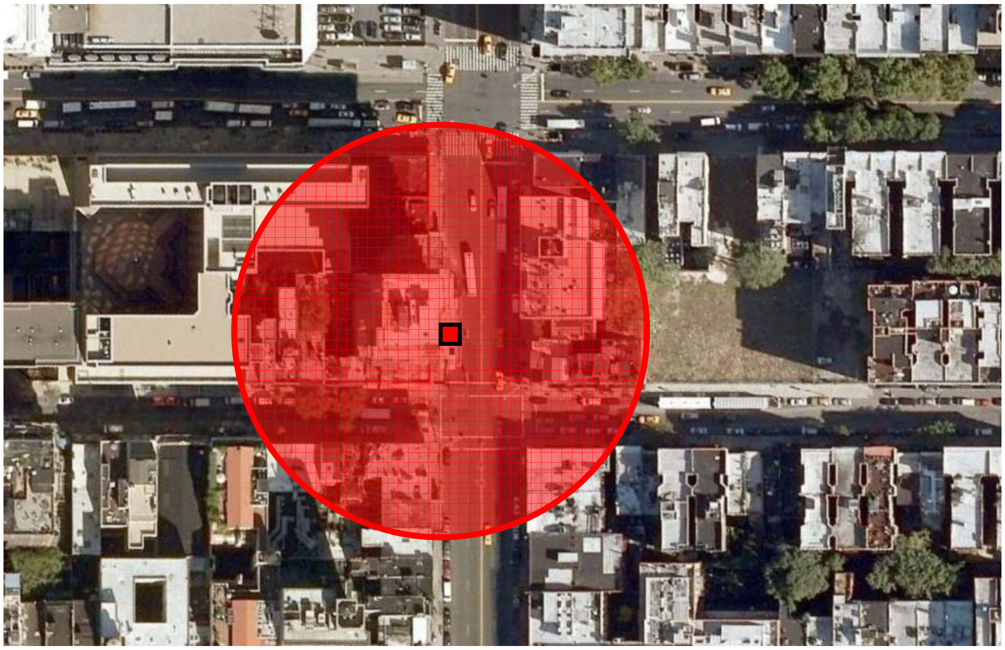


Figure C.1.2: Impact Zone of a Tower Crane Collapse.

The combination of low probability and high variability (and thus uncertainty) of causes of high-consequence crane accidents presents a challenge in promoting safety. Construction risks which are closely tied to a single cause can be addressed by targeted procedures. The variable nature of crane risk requires a broader range of controls to introduce a level of redundancy.

C.3 Site Observations

Cranes

A total of 182 site visits were completed by HRCO crane field teams between July 2008 and January 2009. Of these, there was no crane or no observable crane operations at 14 sites, resulting in 168 actual observations of crane equipment and operations, carried out on 104 individual pieces of equipment (some cranes were observed multiple times). Table C.3.1 provides the type and number of the various types of cranes visited.

The crane team typically sent out one senior inspector to visit each site. The team performed full and targeted visits. Targeted site visits were limited to specific crane safety issues. Full site visits included a broad spectrum of items related to crane equipment and operation. A DOB Cranes and Derricks Unit inspector accompanied the HRCO observation teams during a substantial number of the early site visits. The HRCO completed the later visits alone and reported any potential violating conditions directly to C&D. Observations from site visits were recorded on to standardized *Location Reports*.

The HRCO team essentially observed all available tower crane sites during the period of the study. There may have been a small number of tower cranes that were either being just brought out of or into operation at beginning or end of the study that were not observed.

Type of Crane	Quantity Observed	Quantity with Safety Issue
Tower	42	27 (68%)
Rubber Tired Mobile	28	11 (39%)
Crawlers	20	7 (35%)
Knuckle Boom	6	5 (83%)
Mast Climbers	5	5 (100%)
Other	3	2 (67%)
Total	104	57 (56%)

Table C.3.1 – Types of cranes visited

The majority of mobile cranes were observed in September and October 2008. Forty jobsites were chosen randomly from the outstanding list of permitted cranes. Jobsites in the Bronx, Brooklyn, Manhattan and Queens where selected. Additional mobile crane observations were made based on particular issues of interest.

Hoists

A total of 99 site visits were completed by the HRCO hoist team between July 2008 and January 2009. Because of the relatively little oversight currently applied to hoist machines, hoist sites were selected on a random basis and captured a range of parameters including type (material only and personnel and material hoists), union and non-union operation and configuration of back structure.

Nine of the hoist site observations were targeted to hoist machine owner's shops and storage yards as described in the recommendation for Off-site Controls.

C.4 DOB Process Review and Industry Outreach

DOB Process Review

The HRCO team interviewed all of the Cranes and Derricks Unit's inspectors (through February, 2009) to determine their respective strengths and weaknesses as well as to determine their views regarding the unit and industry. The HRCO crane team also observed inspectors in the field performing their inspection tasks.

In addition to the inspectors, the HRCO crane team interviewed the plan examiners and members of the administrative staff. The purpose of these interviews was to assess the various procedures of the Unit and the functioning of the staff.

Industry Outreach

An important aspect of the overall assessment was to include the various perspectives of the stakeholders in the crane area. To do this, the HRCO moderated three meetings with the NYC industry. The attendees included: crane owners, users, professional engineers, manufactures, union representatives, operators and DOB personnel. The HRCO presented their proposed recommendation and sought feedback from the group. These meeting were valuable in shaping the final recommendations.

DOB and the HRCO also wanted to include other groups that may have a viewpoint for the recommendations. As such, DOB moderated a meeting with other regulatory bodies to share ideas and determine possible directions for the jurisdiction. In addition, the HRCO moderated two meetings with manufacturers to outline the possible recommendations. These groups were also critical in the final development of this report.

There were three new laws enacted in the fall of 2008 to primarily tower cranes. One of these laws required the members of tower crane crews (assembly, jumping and dismantling) to attend a 30 hour course. The HRCO attend a four hour portion of one course to ascertain the curriculum and the class room environment. In addition, the material for two other courses was reviewed for content.

New York State invited the HRCO to attend one of their practical test sites to observe its hoist machine operator test. This was held in Long Island in December. In addition, the HRCO viewed the practical test for the NCCCO on their web site.

C.5 Summary of Recommendations

Recommendations fall into subcategories: Equipment Design, Site Specific Design, Crane Operations, Inspection, Maintenance and Repair and DOB Internal Operations. These categories essentially cover the entire life cycle of a crane, from creation (design and manufacture) through retirement. Recommendations that are specific to hoist equipment come at the end of each category.

Recommendations designated as *Further Study* are those that may require additional investigation on the part of DOB to fully gauge their applicability or usefulness. Recommendations are summarized as follows:

Equipment Design

Approved Manufacturer (C-7)

Replace the current model-specific Certificate of Approval process with one that approves the manufacturer using predetermined, industry-standard criteria.

Older Equipment (C-14) (Further Study)

Require an extensive mechanical crane inspection every 10 years for all cranes and potentially an age limitation for operation in the jurisdiction.

Electric Tower Cranes (C-21) (Further Study)

Have an all-electric tower crane fleet in the jurisdiction by a specified date.

Hoist – Equipment Acceptance (H-1) (Further Study)

Create and implement an Equipment Acceptance Certification program for hoisting equipment employed in the NYC area.

Site Specific Design

Tie-Ins (C-8)

Tie-In connections should be subjected to special inspection and require improved design and erection procedures

Foundations (C-9)

Foundations should be subjected to special inspection and require improved design and erection procedures

Load Test (C-15)

The test weights to be used should not exceed the manufacturer's specification or, in case where the manufacturer is not available, the applicable ANSI standard should be followed.

Counter Weights (C-5)

Counter weight information should be readily available on the drawing and on the counter weight module itself.

Hoist – PE Sign-off (H-2)

Require the building engineer of record or an engineer acceptable to DOB to review that the building can support the loads imposed by the hoist.

Crane Operations

Rigging Safety (C-4)

Establish a DOB sanction group to review current industry practices, how they differ from the regulations, and determine the best means to enforce current regulations. The practice of dragging or side pulling the load should be eliminated. The 30 hour tower crane rigger class should devote a substantial portion of its curriculum on the erection, climbing and dismantling of tower cranes as well as general rigging.

Articulating Boom Crane (C-12)

The definition of “crane” should be changed so that articulating boom cranes are regarded as a special type of crane. This, in turn, would require each such crane to have an annual inspection (Certificate of Operation) and a licensed operator (HMO).

Crane Assembly (C-13)

All assembly, climbing and dismantling of a tower crane must include the on-site participation of a Technical Advisor who is one of the following:

1. A representative from the Original Equipment Manufacturer (OEM)
2. A qualified, factory trained representative of the distributor / OEM
3. A qualified, factory trained owner’s representative

HMO “C” License (C-1)

Require National Crane Operator Certification for Hoisting Machine Operator “C” License Examination.

HMO “A” and “B” License (C-23)

Require all Hoist Machine Operators (HMOs) to have a nationally recognized certificate and ensure each operator has the necessary experience to operate the cranes they use.

Scaffolding Hoist (C24) (Further Study)

DOB should require a plan review and inspection of custom built hoisting systems that are able to hoist loads exceeding 1 ton (907 kg).

Hoist – Riding on Top of Cars (H-3) (Further Study)

Restrict actions of workers riding on top of cars to limit inherent dangers of working on and in close proximity to moving equipment.

Inspection

Third Party Inspection (C-3)

Allow third party inspectors (inspectors from entities independent from DOB and the crane owner or user) to perform the required annual crane inspections needed for the CD permit.

Bolted Connections (C-2)

All bolted connection must be checked regularly. Crane maintenance personnel must have basic knowledge about bolt torquing (see C-R-06).

Tracking Mobile Cranes (C-17)

Require the crane user/owner of mobile cranes to notify DOB prior to the start of a job and when the crane will leave the jobsite. DOB must also be notified if there are changes in the schedule. The notification is required for all jobs that require a Certificate of on-site inspection.

Hoist – ANSI Standards (H-4)

Adopt the ANSI A10.5 Material Hoist standard. Regularly update regulation to reflect current versions of A10.5 (Material Hoist) and A10.4 (Personnel and Material Hoist).

Hoist – Qualified Inspections (H-5)

Introduce a “Qualified Hoist Inspection” Program that establishes the requirements and qualifications of the inspectors performing inspections of temporary personnel and material hoists inspections, as well as the inspection criteria and Drop Test Reports that are filed with DOB after the inspections are performed.

Maintenance and Repair

Maintenance and Repair (C-6)

Repair: The Owner must notify DOB of all major structural repairs while the component is actively registered (has CD) or upon renewal if the CD lapsed

Maintenance: Increase the written maintenance and inspection log requirements to provide more complete records of the work performed on each crane.

Component Tracking (C-20)

DOB should institute a tracking system for the major structural components

Data Recorder – “Black Box” (C-22) (Further Study)

Based upon further study, DOB should consider the use of data recording devices that will provide critical information regarding the operation of cranes within the jurisdiction.

Hoist – Off-site Controls (H-6) (Further Study)

Introduce and implement an Off-site Hoist Equipment Control Program to check that the equipment is adequate for the intended use.

Hoist – On-Site Log Book (H-7)

Require that all site locations maintain an On-Site Hoist Equipment Log to standardize record keeping of all pertinent data.

DOB Operations

Inspector and Examiner Training (C-11)

Assess the various skill sets of the inspectors and plan examiners of the Department of Buildings and provide them the necessary training and tools to complete their tasks effectively and efficiently

Accident Investigation (C-18)

The Crane and Derrick Unit should augment and audit its incident/accident reporting procedure to confirm each file contains the required information and the inspectors' investigation is organized and thorough.

C&D Self Auditing (C-19)

Develop and install a change process whereby the Cranes and Derricks Unit of the Department of Buildings monitors itself and makes adjustments as necessary

RS 19.2 (C-16)

DOB should revise of RS 19-2 and seek industry comments.

Hoist – Regulation of Hoists (H-8) (Further Study)

Hoist equipment (Personnel and Material Hoists and Back-Structures) should be subjected to engineering review, permitting and site inspection by a dedicated DOB department.

C.6.2 Recommendation C-7: Approved Manufacturer

Replace the current model-specific Certificate of Approval process with one that approves the manufacturer using predetermined, industry-standard criteria.

C.6.2.1 Description

The City of New York approves each crane model prior to its operation within the jurisdiction (proto type approval). The basic tenet of this regulation comes from the need to ensure that the cranes operating within the jurisdiction comply and were designed based upon applicable standards and the Department of Buildings having the necessary information to inspect and audit the cranes installation and activities. To shorten the prototype approval process, this recommendation will describe a means to institute an alternative whereby manufacturers are approved versus individual cranes.

To obtain the “approved” status, the manufacturer would have to meet a set of criteria such as: willingness to add the Department of Building onto their safety recall notice list, adhere to a list of standards used in designing and manufacturing cranes, keep DOB informed if substantial changes are made to the cranes, have a commitment to the area to address repair procedures (can be accomplished with a dealer network however the dealer should have technicians trained by the OEM), provide electronic manuals, and possibly others.

The “Approved” manufacturer is common in the internal purchasing procedures of public and private organizations. This method is typically used to shorten the procurement cycle and to use companies that have met specific criteria. For instance, the State of Texas issues a list of preferred manufacturers for school buses, which in turn, are procured by the individual school boards.

C.6.2.2 Recommendation Approach

Persons currently submitting a Certificate of Approval "Prototype Crane Application" can be crane owners, crane rental agencies, crane distributors or any other groups interested to operate a crane. A change of configuration of an already- approved crane (such as adding tower heights, boom or jib length or other major modifications) requires only additional documentation on the specific change to be resubmitted for a new certificate of approval.

Under the current system, an Engineer of Record (EOR) submits the application with the information outlined in DOB's Reference Standard 19-2. This information consists of information supplied primarily by the manufacturer, such as operating manuals, calculations on the design, the material used and the standards used to design the crane, among others.

DOB then reviews the submittal from the technical and administrative perspectives. The Technical review consists of a DOB Plan Examiner (normally a P.E.) checking the plans and technical documents included in the application. The plan examiner formulates questions and objections from his review of the application (DOB form CD-9) and submits these to the applicant's engineer. The applicant in turn revises the application, modifies the submittal and resubmits it to DOB.

During the administrative review, DOB checks the application for completeness of the submitted items, processes the application fee, the data received entered into a database and checked for previous application for that crane model and configuration, and a Prototype-Number is generated for the crane.

Implementation of this recommendation should include the following actions:

- Manufacturers would satisfy predetermined, industry-standard criteria to qualify as an "Approved Manufacturer".
- Establish a simplified process for approving specific crane models and configurations.
- Determine criteria whereby the "Approved Manufacturer" loses such designation.

Manufacturers would satisfy predetermined, industry-standard criteria to qualify as an "Approved Manufacturer".

The following list is proposed by the HRCO crane team, but should be reviewed and amended as necessary. Table C.6.1 contains some of the following in tabular form.

1. For the initial round of approval, the manufacturer should have at least two (2) different models of their cranes already proto-typed. This demonstrates a proven performance track record and a familiarity with NYC requirements.
2. The manufacturer is currently manufacturing the cranes included in the application or willing to support such going forward.
3. The manufacturer adheres to American or internationally accredited design and manufacturing standards and design practices, such as FEM, EN, DIN, ISO, SAE, AS, etc.
4. The manufacturer has an ISO 9000/90001 certification. The cranes that will be used in the Jurisdiction will need to be manufactured at an ISO 9000/9001 certified facility. The certifying agency should be independent from the manufacturer.

5. The manufacturer also comply to the ANSI crane standards (B30), or similar, when designing the cranes.
6. The manufacturer will send updates about safety recalls and bulletins to DOB at the same time as ones sent to the owners. This requirement will be for older models as well as new cranes. DOB will provide the manufacturer a list of the cranes already approved so they may be added to the recall list.
7. The manufacturer has a technical representative (engineer) in the US who will be the designated point of contact for all DOB communication. This representative will have enough technical background to answer most general questions about operating, maintenance and repair procedures for their crane products.
8. The manufacturer has factory-trained technician within a four hour travel window (ideally located in NY, NJ, CT or PA). This may be a different person than the technical representative.
9. The Manufacturer will provide the necessary manuals and technical information on the cranes in use today as well as the new ones. This documentation will include daily, monthly and annual inspection check lists for DOB to add to the third part inspection lists (C-R-03 Third Party Inspection).
10. Provide DOB access to manufacturer training courses for its inspectors when the manufacturer offers them (C-R-11 Training).

Issue	**Example Criteria**
Manufacturing	ISO 9000/90001 certification
Design	FEM, EN, DIN, ISO,SAE, AS, ANSI, etc.
Performance	ANSI
Support	Dedicated liaison to DOB for technical issues and a regional representative available to the city for possible on-site issues.
Notifications	Recalls and bulletins issued to DOB as well as the owner.
Documentation	Manuals, design information

Table C.6.1 – Manufacturer Criteria

Establish a simplified process for approving specific crane models and configurations.

Once the manufacturer receives the Approved designation, they would still be required to submit an application for each crane and maximum configuration to be used in the Jurisdiction. This application would be similar to the one outlined in the current regulations (RS19-2) as this information is needed for DOB to perform some of their duties, such as, but not limited to:

Paragraph 3.1

1. *Affidavit of compliance from the manufacturer as detailed in section 3.2 below,*
2. *Operator's manual showing all configurations for which the engineer is seeking approval, general equipment specifications and manufacturer's recommended maintenance procedures.*
3. *Load rating chart with chart number and page numbers for identification.*
4. *Any supporting data, drawings, or calculations upon request.* **AND** from 3.2

5. *List of all components: maximum boom length, maximum jib(s) length, maximum length of all other attachments,*
6. *List of all counterweight combinations,*
7. *List of standards used in the design of the boom and/or mast,*
8. *List of standards used in the design of the jib and/or extensions.*
9. *List of standards used in the design of the boom support system,*
10. *List of standards used in the design of the counterweight support system and attachments*
11. *List of standards used in the design of the rope.*
12. *List of standards used in design of overturning stability.*
13. *List of standards used in the prototype testing, and*
14. *List of material(s) and material specifications used in the components listed in Numbered Items 3-7 above.*

DOB would process the application by primarily clerical means. DOB administrative staff would audit the submittal to ensure all the required documentation is included. If the package is fully compliant, then the crane would be granted approval status and given a proto-type number. If there is missing information, DOB would send an objection list to the manufacturer requesting the missing information.

Determine criteria whereby the "Approved Manufacturer" loses such designation.

The HRCO crane team proposes that the following be used at a minimum.

1. The manufacturer fails to comply with any of the previous criteria.
2. There is a significant change in the operations of the manufacturer, such as
    - The manufacturer makes significant changes to the personnel in its design department.
    - The manufacturer out sources the crane design or the crane manufacturing to another company.
    - The manufacturer has a major change of management e.g. by merging with another company or being acquired by another company.

If the "approved manufacturer" status is revoked, the manufacturer should re-apply when such conditions are remedied. The cranes that have been previously approved would maintain their Certificate of Approval as long as it was issued prior to the condition that caused the revocation.

C.6.2.3 Additional HRCO Data

Presently, DOB reviews approximately 10 to 20 prototype applications per year. DOB plan examiners generally process the application within a few weeks of receiving information from the Engineer.

DOB has little if any direct communication with the manufacturers and rely on the Applicant’s Engineer to address and answer objections or questions.

The HRCO crane team reviewed seven (7) applications for a Certificate of Approval (Table 6-2). DOB returned four (4) of them with objections and/or comments.

No.	Type	Comments
1	Mobile Crane 1	Only minor issues detected.
2	Mobile Crane 2	Values in manuals should be available in US dimensions. Some calculations missing.
3	Mobile Crane 3	Only minor issues detected.
4	Mast Climber	Issues with wording in manual. Application shows 400V at 50 Hz. AC motors in this application would run 20 % faster.
5	Tower Crane 1	Only minor issues detected. The submittal contains more extensive manuals and appeared acceptable from a high level.
6	Tower Crane 2	Load chart in application deviates from manufacturer's manual.
7	Tower Crane 3	Only minor issues detected.

Table C.6.2: Proto-type Applications Reviewed by HRCO

The following table shows the processing times of crane prototype applications. The average processing time for prototype applications was calculated as 110 days, beginning with the first submittal of the application and ending with the notification to the Engineer of Record (EOR) that the crane prototype was accepted. The date of application was supplied by DOB, and the date of acceptance is derived from the notification letters included in the prototype file.

Date Submitted	Date Accepted	Variance	P No.	Manufacturer	Model	Type
3/2/2007	3/26/2007	24	476	Liebherr Crane	HS 895	crawler, duty cycle
3/26/2007	4/18/2007	23	477	Tadano American Corp.	TM-211D	boom truck
3/26/2007	4/20/2007	25	478	Tadano American Corp.	TM-1882	boom truck
4/2/2007	4/25/2007	23	479	Broderson Manufacturing Corp.	IC-80-3E	industrial mobile crane telescoping, single platform, carry deck
4/20/2007	4/27/2007	7	480	Kobelco	CK 2000	Crawler
4/25/2007	5/30/2007	35	481	Liebherr Crane	LR 1300	Crawler
7/11/2007	2/21/2008	225	484	Manitowoc	1015	crawler, duty cycle
8/10/2007	10/18/2007	69	486	Liebherr	355 HC-L-12	tower, luffing jib
8/15/2007	11/2/2007	79	487	Liebherr Crane	LR 1250	crawler 250t
8/21/2007	8/31/2007	10	488	Liebherr	LTM 1130 - 5.1	mobile crane 2 cab 130t
8/21/2007	12/6/2007	107	489	Potain Manitowoc	MR 295	Tower crane
8/24/2007	12/11/2007	109	490	Potain Manitowoc	MR 415	Tower crane
10/12/2007	12/11/2007	60	491	National Crane	13110A	truck crane, 2 cabs, 30t
10/17/2007	1/10/2008	85	492	National Crane	13110H	Boom truck
11/29/2007	12/11/2007	12	495	Manitowoc	14000	Crawler
12/19/2007	5/19/2008	152	496	Terex Demag	AC 55 Cay	mobile, single cab telescoping inner city
12/20/2007	6/18/2008	181	497	Terex Demag	AC 140	mobile crane telescoping, dual cab
12/20/2007	5/20/2008	152	498	Terex Demag	AC 200 - 1	mobile crane dual cab

1/3/2008	5/19/2008	137	499	Grove	RT 540 E	rough terrain crane
1/15/2008	7/21/2008	188	500	Liebherr	LTR 1100	crawler 110t telescopic boom
3/10/2008	7/25/2008	137	503	Liebherr	HS 885 HD	crawler 130t duty cycle
3/17/2008	8/4/2008	140	504	Terex	HC 230	Crawler
3/18/2008	7/23/2008	127	505	Tadano	TM - 1052	boom truck
4/17/2008	2/4/2009	293	506	National Crane	900 H	boom truck
5/1/2008	9/29/2008	151	508	Link – Belt	298 HSL	crawler 230t
6/25/2008	4/9/2009	288	509	Liebherr	376 - EC - H .12	tower crane, fixed jib
7/23/2008	11/20/2008	120	510	Grove	GMK 7550	mobile crane 550t
9/11/2008	1/12/2009	123	514	Liebherr	LR 1280	crawler 280t
10/1/2008	1/23/2009	114	516	Manitowoc	16000	crawler 440t
10/14/2008	1/20/2009	98	518	Link belt	RTC - 8050 II	rough terrain crane 50t

Total Applications Reviewed: 30
Average Processing Days 110

To help explain the lengthy time frame, the HRCO team interviewed DOB personnel. The following issues were identified:

- Engineer of Record (EOR) supplied incomplete applications (see tables below) and then took time to answer DOB's objection points.
- In 2008, the prolonged times were also a result of DOB examiners spending time with the forensic teams on the two major crane accidents.

DOB and the HRCO crane team reviewed seven prototype applications. The average duration was 144 days from the submittal by the EOR to the approval. The results showed that DOB required 55 days and the EOR needed 89 days to address the objections and provide a complete set of documentation. Below are tables that outline these proto-type file reviews.

P391, - Amendment Liebherr LR1160, Crawler

Date	Action	days DOB	days EOR	days for approval
2/2/2009	DOB receives application			
2/27/2009	fee paid		25	
4/9/2009	approved by DOB	41		
		41	**25**	**66**

P438, Amendment Liebherr 540 HC L12 Tower Crane

Date	Action	days DOB	days EOR	days for approval
5/5/2008	DOB receives application			
7/14/2008	approved by DOB	70		
		70	**0**	**70**

P446, - Amendment Liebherr LTC 1055-3.1, Mobile Crane Telescoping Single Cab

Date	Action	days DOB	days EOR	days for approval
1/26/2009	DOB receives application			
2/26/2009	objection sent to EOR, no fee	31		
4/9/2009	up to now no answer from EOR		42	
		31	**42**	**73**

P502, Link-Belt 218 HSL, Crawler (Not Included In Final Calculation)

Date	Action	days DOB	days EOR	days for approval
3/7/2008	DOB receives application			
7/18/2008	objection sent to EOR	133		
4/9/2009	up to now no answer from EOR		265	
		133	**265**	**Ongoing**

P506, National Crane 900 H, Boom Truck

Date	Action	days DOB	days EOR	days for approval
4/17/2008	DOB receives application			
6/26/2008	objection sent to EOR	70		
1/29/2009	DOB received answer from EOR		217	
2/4/2009	approved by DOB	6		
		76	**217**	**293**

P509, Liebherr 376 EC - H.12 Tower Crane

Date	Action	days DOB	days EOR	days for approval
6/25/2008	DOB received initial application, then EOR calls to put application on hold for reconfiguration of crane			
9/22/2008	DOB receives revised configuration from EOR		89	
9/29/2008	objection sent to EOR	7		
10/29/2008	DOB received incomplete answer from EOR		30	
4/7/2009	DOB received complete answer from EOR		160	
4/9/2009	approved by DOB	2		
		9	**279**	**288**

P510, Grove GMK 7550, Mobile Crane Telescopic Dual Cab

Date	Action	days DOB	days EOR	days for approval
7/23/2008	DOB receives application			
9/29/2008	objection sent to EOR	68		
10/6/2008	answer from EOR received		7	
10/12/2008	answer incomplete, second objection sent	6		
11/20/2008	DOB received complete answer from EOR		39	
11/20/2008	approved by DOB	0		
		74	**46**	**120**

P518, Link Belt RTC 8050 II Rough Terrain Crane

Date	Action	days DOB	days EOR	days for approval
10/14/2008	DOB receives application			
12/4/2008	objection sent to EOR	51		
12/17/2008	answer from EOR received		13	
1/20/2009	approved by DOB	34		
		85	**13**	**98**

The above prototype application list also shows that a large number of the applications are for cranes from leading manufacturers. These manufacturers would likely be among those initially submitting for the approved manufacturer process.

The HRCO crane team interviewed four of the primary manufacturers to determine their interest in an "Approved Manufacturer" designation. Their initial response was overwhelmingly supportive. They generally agreed with the criteria listed above and showed willingness to participate in the process.

In terms of benchmarking, there are only a few public jurisdictions that have specific crane model approval requirements. Below are the ones that have some form of crane approval prior to it being operated within their borders.

Singapore has approved twenty-one (21) models of tower cranes that may operate within their country between 2006-2008. This list also includes the approved configurations of these cranes. The stated objective is to “ensure that the tower cranes brought into use in Singapore meet the mandatory and regulatory requirements for safe operation.

The procedure is:

- The suppliers (manufactures or agents) or owners submits an application for the type approval of their tower crane using the prescribed application form and procedures describe in this document.
- The applicant must submit one application for each model of the tower crane for type approval.
- Upon successful application for the type approval, the department will issue a Type Approval Document for that model of tower crane.

The criteria that the agency uses comprise of the following items:

- The cranes must be designed to an internationally recognized standard (SS, ISO, EN, BSI, FEM, ANSI, DIN, ASME)
- The design must be verified by a third party inspection agency
- The manufacturer must put in place an accredited Quality Assurance System that is reviewed or audited periodically.
- The model shall meet the legal and procedural requirements, including but not limited to the provision of the safety devices/features as listed.

Cal-OSHA require that various cranes (tower and mobile) be designed to the ASME code written for that particular crane (Title 8, Subchapter7, group 8, §4884).

New Zealand Design verification is required for all cranes including second-hand cranes brought into New Zealand.

Two options are available for this process:

(1) By Design Certificate:

Design verification by design certificate may be used for imported cranes from recognized manufacturers producing standard cranes, designed and built to an acceptable engineering standard

In all cases, where proven standard production model cranes are produced by manufacturers of established repute, subject to the following requirements, the crane can be accepted for design verification and fabrication inspection purposes on the basis of the manufacturer's design statement

The documentation required for design verification includes:

(a) *A statement signed by the chief design engineer, or other person authorized (in writing) by the manufacturer to sign such documents, stating the standard that the crane was designed and built to and that an independent design verification has been carried out. This shall be to a standard acceptable to the Department of Labor, e.g. BS, AS, EN, ANSI, DIN, ISO, JIS, NZS and any others that may be gazetted at a later date (refer to Appendix C).*

(b) *Sufficient data, drawings, documents and other information to readily identify the crane and all of its major components and parts supplied by the manufacturer or replacement parts that are authorized and approved by the manufacturer*

C.6.3 Recommendation C-14: Older Equipment

Require an extensive mechanical crane inspection every 10 years for all cranes and potentially an age limitation for operation in the jurisdiction.

C.6.3.1 Description

As with most construction equipment, a crane and its components have useful lives. Using it past this time increases the risk of potentially hazardous failures. In a dense urban environment, this places many people at risk within the potential crash zone of a tower or large mobile crane.

An age-survey of the active cranes in New York City indicates that 41% of tower and 10% of mobile cranes are older than 20 years and 23% of tower and 9% of mobile cranes are older than 30 years. This recommendation proposes heightened inspections and possible age limitations to address this concern.

Figure C.6.1: Example of Older Equipment (Site 48)

C.6.3.2 Recommendation Approach

The goal of the proposed 10-year inspection should be the evaluation of all safety related and load bearing components to assess their condition and to assure a safe operation until the next inspection of the component takes place.

An inspection plan/checklist indicating the items to be inspected and the type of inspection (e. g. “visual”, “measurement and comparison to manufacturer recommended values” or “NDT”) should be prepared by the following entities, in order of preference:

1. The Original Equipment Manufacturer (OEM).
2. A qualified OEM distributor or OEM local representative with a letter of the OEM delegating this type of service work to the distributor or representative.
3. A Professional Engineer with experience in crane inspection if the OEM is not available.

Details of the inspection plan could include the following as well as any additional items that the above requires:

- Measure the turntable / slewing ring play in several directions and compare these with the OEM specified tolerances. If any measurement fails to meet the OEM minimum specifications or if such specifications are not available, the slewing ring should be repaired or replaced.
- Removal of at least 20 % of the slewing ring fasteners. These should include, at a minimum, the upper bolts in the boom/jib or counterweight/jib direction. These are visually checked for possible elongation and subjected to nondestructive testing (NDT), if there are any signs of cracking or elongation, all slewing ring fasteners must be replaced. As an alternative, all slewing ring fasteners are replaced without checking.
- Disassembly of all gearboxes for hoist and boom drives and brakes, if their components are not visible from the outside. Visual inspection and checking for wear of components like bearings, shafts, axles and gears. NDT or replacement of components, which would cause the load to slip or fall (e.g. various shafts, brake disks, gears, brake actuators).
- Inspection for wear and fatigue of all valves and hydraulic motors that hold, bear or control load movement and braking, and calibration and functional testing of these components after reassembly.
- Hydraulic cylinders should undergo a load holding test for at least 30 minutes to test for creep and leakage.
- All hydraulic hoses should be checked for signs of wear or deterioration and replaced if warranted.
- Sheaves and sheave bearings should be checked for wear and replaced if warranted.

- Telescoping booms should be disassembled to allow inspection and NDT of interior components and boom parts that are hidden in normal operation.
- All relay contacts, cable terminations, wiring, electrical components and enclosures should be inspected for worn / damaged insulation, signs of heat/burning and possible water ingress.
- Load bearing bolts and pins should be removed for inspection and subject to NDT.
- All load measuring devices should be recalibrated.

All components with defects or issues must be replaced or repaired as recommended by the OEM (see C-R-06, Repair and Maintenance). The reassembled crane must be load-tested with 100% rated load including all moment and a load holding test, including each outrigger (see C-R-15, load testing). For mobile cranes any overload warning devices should be tested as recommended by the manufacturer or the Engineer of Record.

This 10-year window for extensive inspection could provide an approach for identifying the “useful life” of a crane. A qualified inspector (see C-R-03, qualified inspector) would submit a detailed report of the inspection (including replacement part list) to DOB. This report would include a statement that the crane is fit and for safe operation and a set of conditions and requirements set by this inspector for the Owner to follow until the next major inspection. Some of these conditions and requirements may include:

- A change in the routine inspection schedule
- Special inspections at designated time intervals
- An extensive inspection at an earlier date than 10 years
- Install a device to count load/stress cycles

If the qualified inspector cannot provide this program for continued use, the crane would be deemed to have reached its “useful life”, and removed from service in NYC and the crane’s CD revoked.

Both NYC and OSHA require various crane components be inspected on frequent and periodic bases. These inspections are primarily exterior, visual inspections or exterior NDT inspections performed on directly accessible components or ones that can be accessed with minimal preparation. Some safety related or load bearing components are hidden from a visual inspection. These are subject to wear and fatigue.

Most crane manufacturers recommend long term inspection and maintenance requirements for components either in their manuals or when requested by the crane owner. There is no industry standard or a scope of long term inspection requirement specified by DOB.

Figure C.6.2 provides a tower crane age analysis that were in operation 1/29/09. In summary, 17 out of 34 tower cranes (50%) are more than 10 years old, and 23% are older than thirty (30) years. The tower cranes over 30 years are primarily FMC TG1900 (62.5%) and Favco Model STD 1500 (37.5%).

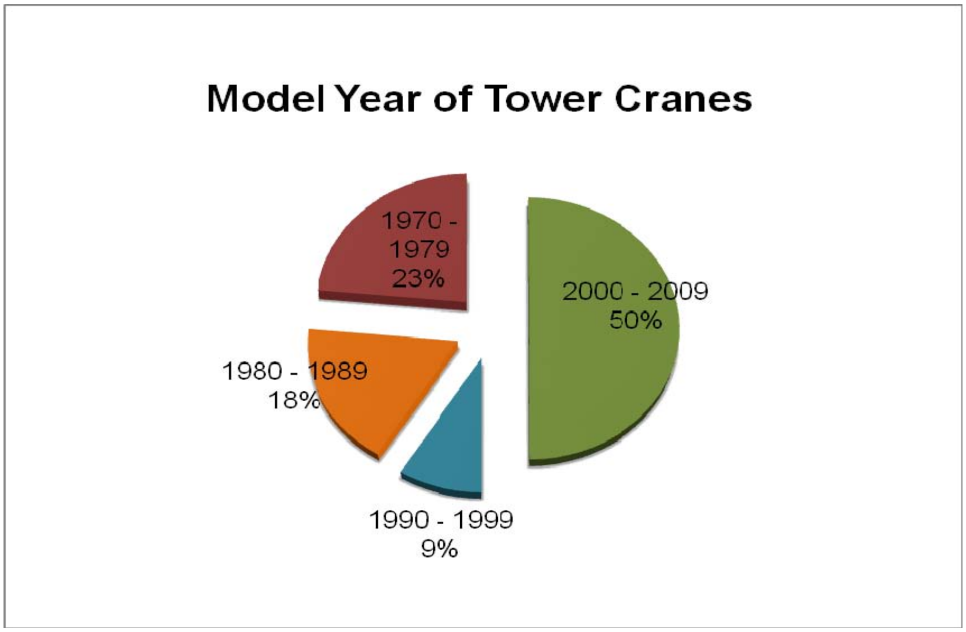


Figure C.6.2: Tower Crane Age Distribution

Figure C.6.3 shows the age of mobile cranes registered with a NYC CD (certificate of operation). The results show that 209 out of 593 mobile cranes (35%) are more than 10 years old, and 9% are older than thirty (30) years.

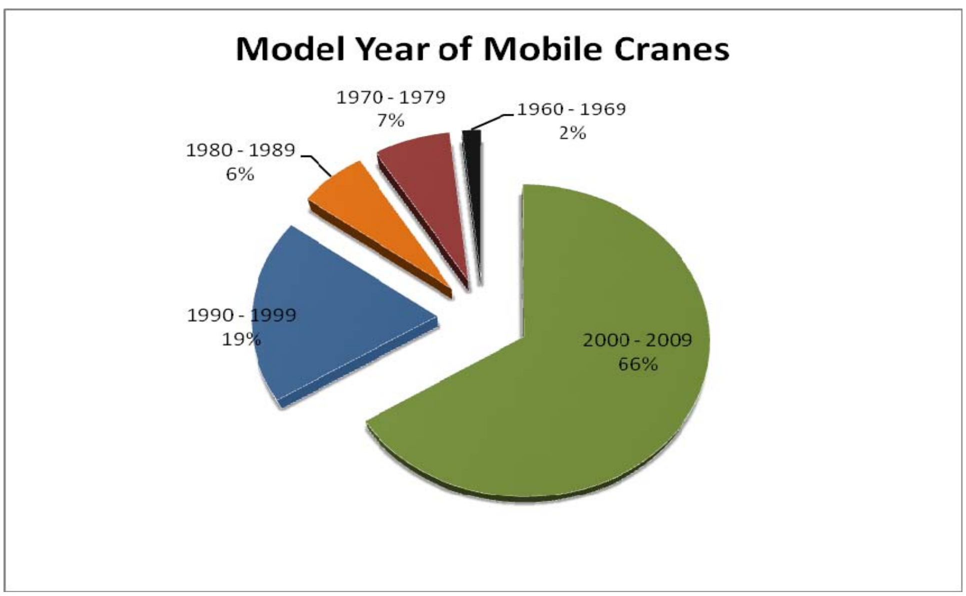


Figure C.6.3: Mobile Crane Age Distribution

The relationship between the increased potential for equipment failures with increasing age can not be ignored. Recently, a crane suffered an equipment failure that caused an abrupt drop of the load (a concrete bucket reportedly weighing approximately 15,000 lbs). The cause of the failure was a worn drive shaft (see Figure C.6.4). The crane and the failed component were reported to be over ten years old. This component is not accessible to observation without a detailed inspection procedure as outlined above.

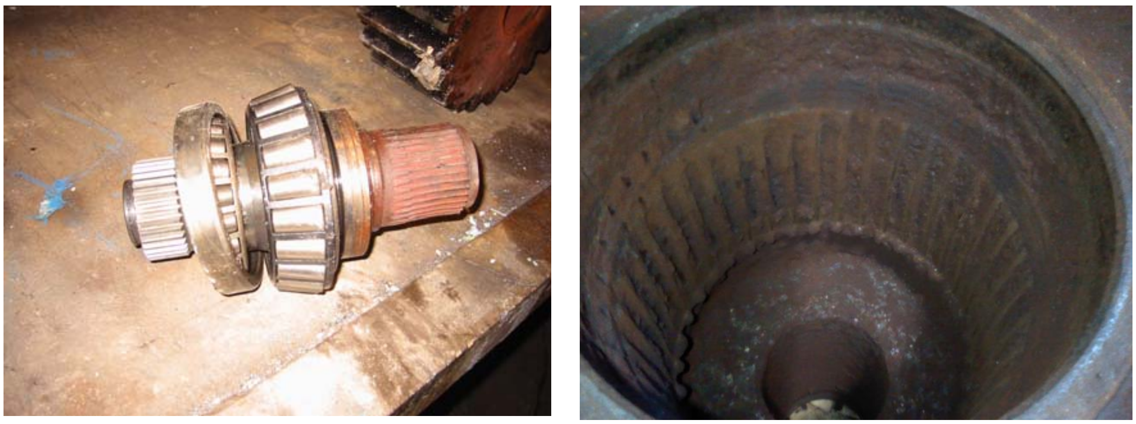


Figure C.6.4: Worn Pinion and Pinion Spine

C.6.3.3 Additional Considerations for Good Practice

The initial application for a certificate of operation for a used crane should require a statement by the manufacturer or its distributor that the crane still receives manufacturer support. DOB should not allow the registration of used cranes which are not supported by a manufacturer.

Age limits and manufacturer support are not included in DOB requirements to receive a certificate of operation (CD) for a used crane. All that is currently required is for the crane to have a valid a prototype certificate and pass the inspection.

Manufacturer support is extremely important for all cranes, and becomes even more critical for aging equipment. Reasons for this include:

1. Manufacturers provide service bulletins regarding performance issues that arise with cranes that are in operation.
2. Manufacturers are the most appropriate source for information on conducting repairs or retrofits to aging equipment.
3. The manufacturer is in the best position to assess the intended service life of a crane and its components based on their original design.

A study should be undertaken to determine the role of fatigue as it relates to useful life of cranes.

Steel structures, which are subjected to stress fluctuations or reversal, are subject to fatigue. As such, cranes designed in Europe use engineering standards that require the manufacturers to use formulae that calculate specific fatigue strength based upon the projected stress cycles. It is not unusual for a manufacturer to perform such calculations, but they are generally deemed proprietary and not available to the public.

If the number of stress cycles is exceeded, fatigue cracks will eventually start to appear. If these are not detected and repaired between when they first appear and the time of “rapid crack growth” the component will fail. With increasing fatigue this time window becomes shorter. There is further discussion of this in “Fatigue Design Basis” section.

DOB should work with the industry and manufacturers to determine the useful life of a crane or of their components via an engineering based approach. Consideration should be given to the fact that cranes in NYC often operate in densely populated and high traffic areas placing many people at risk that live and work in the potential crash zone. There is further discussion of this in section C.6.3.4.

There is currently no age limit on cranes operating in NYC. The industry replaces cranes for reasons including increased maintenance cost, decreased reliability, obsolescence, and/or higher productivity of newer equipment.

The NYC DOB requires Owners to subject the tower mast, jib and booms sections to NDT prior to the tower crane being assembled. In these inspections, tower and mast sections are rejected for a failed test. One such mast section was rejected when 2 out of 8 foot plates failed the NDT (Site C-95).

In various meetings with DOB, HRCO staff and manufacturers, manufacturers did not provide information regarding the useful life of their equipment. One representative maintained that a crane could have an “infinite” life but qualified this by noting that inspections and on-going maintenance and repair are necessary in assuring safe crane operation and that the frequency of required inspections and repairs will increase with the age of the crane.

Within the scope of the current investigation, the HRCO team could not collect sufficient information to establish crane retirement based on age or other criteria (such as inspection results or service history). A further investigation of this topic is required.

During the course of the HRCO investigation, one specific crane model became the source of investigation for fatigue-related failures. Investigations by DOB were on-going at the time of preparation of this report, so detailed findings were not available to the HRCO. But, as reported to the HRCO crane team, multiple cranes of the same model exhibited similar fatigue crack development.

The findings of such failure studies, which would differentiate between systemic and localized issues, should be used as the basis for assessing the risk of specific crane models and determination of conditions for their operation in the jurisdiction.

Cranes that lack certain design safety features should be updated with appropriate components to meet the newer standards or not be used in the city.

Older cranes generally have less advanced safety features. However, to equip the older cranes with some updated components may require a major rebuilding effort.

A common short-coming of older design is the limited access to the outermost tower bolts. In order to reach them, riggers must climb onto a platform that is attached to the outside of the tower. This platform is lifted into position on the outside of the tower using the crane and its position must be detached and reattached with each climbing section. In addition the tower crane rigger often has to change hook points for his safety harness. On 9/4/08 (Site C-94), an experienced tower crane rigger fell from a detachable, crane suspended work platform and died. A few weeks later on 11/12/08 (Site 49) the HRCO team witnessed a similar situation where a rigger climbed onto such a platform without a harness.

Newer tower cranes utilize different tower designs. This design does not require the worker to ride the load, and he can remain on a platform to change pick points during assembly, climbing or dismantling process. Tower bolts can either be reached without the use of an outside platform or a platform which remains attached to the climbing frame. This minimizes the danger of a fall or of being crushed by suspended loads (figures C.6.5 and C.6.6).

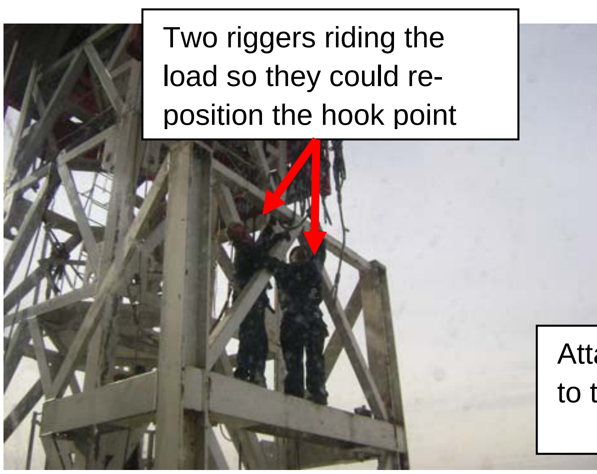


Figure C.6.5: Riggers "Riding the Load"

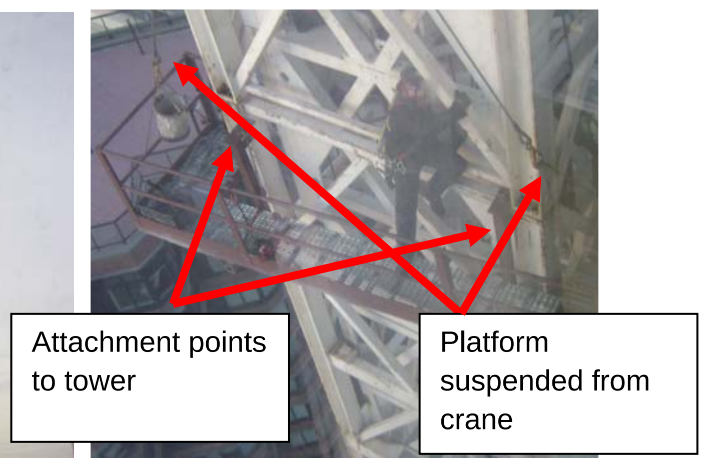


Figure C.6.6: Rigger Kicks Platform to Free It

On older mechanical mobile cranes, the different hoist drums for the boom and load hooks are driven by a single combustion engine. Using friction couplings, the different hoist drives are engaged or disengaged from the main engine by the operator while the engine is running. In addition, the operator must engage/ disengage the hoist brakes for the different hoists to move the particular hoist drum. The process of releasing the brake and engaging the coupling must take place at the same time without any jerking movement requiring skill from the operator (similar to starting up a car with a manual transmission on an incline).

It is extremely difficult to install a safety device that automatically shuts down a hoist drum or boom drum on this type of crane. Newer cranes with hydraulic or electric drives automatically stop hoisting or booming (e.g. in case of two-blocking which could cause the boom or jib to break) when the load moment becomes too large (danger of tip over) or when the maximum line pull force is reached. With the older mechanical cranes these safety aids can only give an acoustical and optical warning to the operator

On 7/21/05, the boom of a mobile crane with mechanical transmissions broke off, because the operator's foot slipped off a foot-pedal that caused a jerking hoist-drum movement. With newer hydraulic or electric cranes, acceleration and deceleration of components are dampened either by limiting valves or by more sophisticated control mechanisms so that a brief abrupt movement of the controls is less likely to create shock loading on the crane's structure***.***

DOB grandfathered older cranes when it made certain safety aids mandatory (for instance, anti two blocking sensors for the Manitowoc 4100). In other cases DOB demanded retrofitting. There were two instances (3/9/05 and 6/29/07) where a grandfathered crane did not have an anti-two block device resulting in damage to the crane.

Therefore, primary items to consider would be:

- Larger mobile cranes (those that require a Certificate of On-site Inspection) should include features that automatically stop hoist or boom movements when an operational aid alerts the operator of a potentially risky situation. This includes but is not limited to:
    - Anti two blocking device,
    - Load moment monitoring devices (having a rated capacity limiter instead of a load and/or capacity indicator).
    - Maximum and minimum boom automatic angle shutoffs (instead of stops only).
- Tower crane designs should minimize the situations where the tower crane riggers must "ride" a suspended load or work on platforms suspended from the crane hook.

C.6.3.4 Additional HRCO Observations

There are a few public jurisdictions that require either assign a useful life or require more in-depth inspections as crane age. Below are the ones that have attempted to address this area.

> **The Australian** standard 2550 (Cranes, Hoists and Winches – Safe Use) requires that cranes and lifting equipment undergo a Certification and Refurbishment when they have reached the end of their design life, (or where this is unknown after 25 years for the structure and 10 years for the mechanical). This includes a major inspection to assess their suitability for continued safe operation.

Singapore limits the service life of mobile cranes per the following schedule:

Design Safe Work Load (Max. Capacity)	Maximum Allowable Service Life (Mobile Crane)
mobile crane up to 50,000 kg [110,230 lbs]	20 years
mobile crane above 50,000 kg [110,230 lbs], up to 100,000kg [220,460 lbs]	25 years
mobile crane 100,000 kg [220,460 lbs] and above	30 years

Cranes exceeding the maximum service life need a "thorough assessment" by an approved 3rd party agency and approval by the MOM ("Ministry of Manpower" agency regulating construction work safety). This includes a proposal detailing *"Usage Patterns (e.g. number of operating cycles per hour at certain load condition)"* and a *"proposed scheme to evaluate the remaining service life of the crane"* including "*The methodology and assessment employed including testing and inspection to be carried out to address potential fatigue stresses experienced by the crane"...*

Singapore limits the service life of tower cranes per the following schedule:

Previous History of Crane	Maximum Allowable Age, for Use in Singapore
used tower crane from overseas not registered	10 years
used towercrane not registered	15 years
registered towercrane	15 years, can be extended with manufacturers certificate
all other tower cranes	20 years

New Zealand regulations include the following: "*As the end of the national design life of a crane approaches… at periodic intervals or when a second-hand crane is imported into New Zealand, inspection and testing shall be carried out in order to determine that the crane will remain safe for continued use. … If there is insufficient information to enable the equipment inspector to make a proper assessment of the condition of the crane, the inspection body shall not certify it*

Fatigue Design Basis

Europe addresses fatigue of a crane's metal structures by using the number of stress cycles a particular component undergoes. The service strength of a steel structure is influenced by the quantity (number) of stress cycles, the magnitude of the stress range, notch effects and steel grade.

The European standards classifies fatigue design of tower crane components relative to anticipated stress cycles ranging from 600,000 to 1.5 million. The stress magnitude is determined by the full stress range experienced by a component as it cycles from compression to tension and variations between the two. Finally, they consider the notch effect, which is a function of the shape, structural design, hole pattern or type and quality of the weld.

Depending upon the magnitude of the above, the allowable stress on a steel structure is reduced accordingly. The fatigue stress on the crane is introduced by repeated lifting and releasing loads and slewing of the crane. Wind influence is not considered when calculating fatigue.

As equipment approaches the service life (or fatigue limit) very small, and perhaps undetectable flaws, can grow at a rapid rate to a critical crack size that could cause failure. Procedures exist to estimate the number of cycles required for a flaw to propagate to a critical crack (one such is the Paris equation). This parameter of crack growth rate is necessary to determine the inspection interval that would be necessary for a crane that could be operating beyond its fatigue life.

Thus the essential logic for fatigue analysis of a crane involves:

1. Establishing the original fatigue design basis of the individual crane components (number of cycles and stress magnitude).

2. Determining the actual number of cycles experienced by a specific crane component. This could be accomplished in the future by mating data loggers ("black box") with component tracking. In the absence of such technology, it requires estimates of cycles. A crane in steady use might accumulate on the order of 600 cycles per week, or 30,000 cycles per year.

3. Comparison of the actual service history with the design basis provides a measure of remaining life. It should be noted that this assumes the crane has been properly operated and has not been significantly overstressed – in which case the fatigue life could be significantly reduced. The application of data logging technology could serve to provide insight into whether crane components had been overstressed.

4. As a crane component approaches the fatigue limit there is an increased potential for relatively rapid development of fatigue cracks. At this point, the component could either be removed from service or, in theory, carefully monitored for crack development. Monitoring would require a determination of how quickly a crack could grow from

undetectable to hazardous. The inspection method and frequency would then need to be sufficiently conservative to ensure identification of fatigue crack growth at its early stages.

Airline Industry

The airline industry has recognized for many years the importance of applying stricter maintenance and repair systems on aging aircraft.

For the commercial aviation fleet, Congress passed the Aging Aircraft Safety Act of 1991 to address aging aircraft structural concerns resulting from the April 1988 accident involving a Boeing B-737. This noted failure (Aloha Airlines flight 243, NTSB Report # AAR-89/03), which was caused in part by fatigue issues, precipitated an overhaul of maintenance and repair procedures for aircraft. The commercial airline industry has an advantage over construction cranes in that the record keeping is far more advanced. For example, after the failure of Flight 243, the FAA was able to release flight restrictions and inspection requirements specifically for B-737's with more than 30,000 landings, because detailed flight information was available from which to identify an age threshold at which planes might be at risk. Similar operational data, with which to establish the functional age of cranes and crane components, is not currently available.

Similar attention is being paid to aging aircraft in the general aviation fleet (typically smaller, private aircraft). Two aspects of best practices are currently being promulgated by the FAA: Airplane Record Research and Special Attention Inspection. Airplane Record Research provides a basis of information by compiling flight histories for the specific aircraft combined with operational records for its make and model. Special Attention Inspection recognizes that normal annual inspection may not be sufficient for aging aircraft and that more detailed inspections and rehabilitations may be needed to keep the aging aircraft at an acceptable level of reliability.

C.6.4 Recommendation C-21: Electric Tower Cranes (Further Study)

Have an all-electric tower crane fleet in the jurisdiction by a specified date.

C.6.4.1 Description

Electric crane use is increasing for a multitude of reasons including environmental concerns and cost of operation. While those considerations are outside of the scope of the HRCO study, some aspects of electric crane use could positively impact crane operations in New York relative to safety. Thus, if there is a general move toward electric tower cranes, the HRCO crane team supports this for the following reasons:

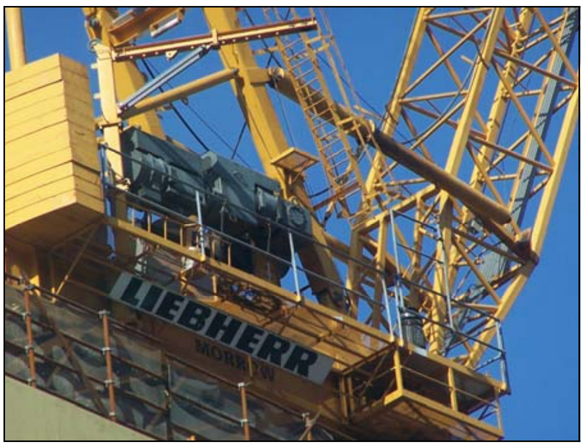


Figure C.6.7: Electric Crane

Figure C.6.8: Diesel Hydraulic Crane

- **Provision of a modern crane fleet**. This is the primary benefit of moving to an all-electric fleet. This would provide an opportunity to phase out older equipment lacking modern safety features.
- **Removal of refueling operations**. A typical diesel crane uses up to 10 gallons of fuel per hour and requires refueling every few days. This usually requires hoisting drums or tanks of fuel to the machine platform. This presents a very small but obvious risk of hoisting and handling flammable substances.
- **Electric cranes require less hydraulic fluid.** The primary reason is that the diesel machines require the fluid for their hoist drives, while electric cranes normally have a small amount of hydraulic fluid used in brakes and the climbing frame cylinders. There were two leaking incidents in NYC while the HRCO team was on assignment, both involving the same crane. The first one the HRCO team observed while investigating a crane (see Figure C.6.9), and the second time a hydraulic fitting failed and hydraulic fluid spewed into the street below requiring a HazMat response and clean up.

- **Diesel crane engine noise levels exceed 90 dBA**. Electric cranes operate at less than 80 dBA. This is a significant difference, relative to hearing health, for anyone working in vicinity of the crane.

Figure C.6.9: Leaking Hydraulic Fitting

C.6.4.2 Recommendation Approach

The final time frame should be selected so as to provide sufficient notice to owners and operators so they may adjust their crane usage and fleets.

A number of logistics would need to be investigated for this recommendation. For example, electric cranes require an electrical power source. Most buildings should have sufficient power from the electrical grid by the time the tower crane arrives on site. But, this will require some coordination between the user, the City and the electric company.

C.6.5 Recommendation H-1: Hoist Equipment Acceptance (Further Study)

Create and implement an Equipment Acceptance Certification program for hoisting equipment employed in the NYC area.

C.6.5.1 Description

There is no current requirement, or standardized quality assurance program to ensure hoist equipment in use in NYC is in compliance with standard industry quality assurance practices for design, manufacture, materials, testing, and that it is in compliance with all applicable regulatory specifications. This recommendation proposes an Equipment Acceptance Certification that would require Hoist Contractors to certify that the equipment employed by them has satisfactorily passed minimum quality requirements.

For the most part the hoist industry is not required to provide or record quality assurance information for their equipment and as such they typically don't require it from their suppliers. Contractors will simply buy a hoist, mast, or mechanical drive parts without requiring quality assurance certifications. Additionally, some contractors manufacturer their own equipment but not necessarily with any specific quality control program in place.

During the course of this study the HRCO hoist team visited 6 hoist contractor facilities. All of them but one performs some form of fabrication or major repairs. Aspects of contractor QA/QC procedures are summarized in Table C.6.3 and discussed below.

Of the five contractor facilities that have shops for fabrication and repair, only two maintain some manner of quality control program. These two facilities have extensive operations, performing major modifications to their cars and mast sections (one facility even fabricates their own mast sections). Quality procedures at these two facilities include:

- quality inspections on the mechanical drives and rebuild or repair any defective parts
- mast sections are UT tested and have identification numbers for traceability
- in-shop testing of assembled cars (including drop tests)

However, neither actually has a formally documented quality control program.

A third contractor had no quality control program, though they do perform UT and then tag tested sections but only at the client's request. They also perform car testing in shop.

The remaining 2 of the 5 contractors that perform fabrication and repair work exercise very little quality assurance. One of them makes major repairs to the majority of their mast section inventory without qualified welders. The welder observed by the HRCO hoist team was not AWS or New York State certified. This contractor also did not have the means to shop test their cars, although there were at least aware of the potential for internal corrosion of mast legs perform UT testing before returning them to service.

None of the contractors required quality assurance information from the suppliers and manufacturers that they buy their equipment from. And although many of them are buying premium products from established manufacturers, just as many are buying "cloned" products.

One contractor purchases less expensive “cloned” equipment and then rewires the entire car to meet UL standards, removes and replaces floor plates and cage, and removes and replaces the gearing in the drive. They claimed that after one installation with the “cloned” parts, the gears wear out. So they replace them with a German made product from the outset.

Table C.6.3: Summary of Hoist Contract QA/QC Practices.

Contractor	Formal QA/QA program?	Requires QA/QC from Supplier?	Degree of informal QA/QC
#1	No.	No.	Moderate
#2	No.	No.	Moderate
#3	No.	No.	Little
#4	No.	No.	Little
#5	No.	No.	Little

C.6.5.2 Recommendation Approach

Hoist contractors would certify that equipment in service meets or exceeds specific criteria. The criteria could include:

1. Design of such equipment has been performed by a qualified engineer, for example, as demonstrated by a minimum of 10 years experience in the design of similar type equipment.

2. Manufacturer of equipment is certified to a relevant quality assurance program (e.g. AISC certification). The quality program should be documented in a manner that can be submitted to DOB.

3. All weld procedures, including weld process qualification reports (WPQR), weld materials, weld process specification (WPS), and welder qualifications, must be in accordance with AWS D5.1 or D5.5, as required.

4. All materials are as required by design and are mill certified.

5. Product testing is to be performed on all products to confirm load ratings.

6. All in-service equipment must be in its original manufactured configuration. Any parts that are replaced or repaired must meet Original Equipment Manufacturer (OEM) standards.

7. Gearing, bearings, shafting, brake liners, housings, cable, rollers, limit switches, must all be by original OEM products or be by approved manufacturers.

C.7 SITE SPECIFIC DESIGN

C.7.1 Description

This section addresses issues that relate to the overall site design of tower and large crawler cranes. This includes foundations for tower and crawler cranes and building tie-ins for tower cranes. Many times these site-specific design elements are altered during crane erection due to unanticipated site conditions.

Recommendations for tie-ins and foundations serve to expand and strengthen engineering efforts by crane and building engineers as well as DOB plan examiners. No matter how well designed, manufactured or maintained, if a construction crane is not properly supported, it could be subject to catastrophic failure.

Tower and large mobile cranes rely on counterweights to support lifted loads. Proper configuration of the counterweights (as well as general functioning of the crane) is confirmed by a load test prior to putting the crane into service. Recommendations for load tests and counterweights primarily take practices already recommended in standards and by manufacturers and formalize them for NYC.

The further study recommendation for wind loading is related to the understanding that local wind loads in urban environments can vary significantly from standard wind load charts. A related recommendation for high-rise concrete calls for increased monitoring of actual wind speeds in Manhattan. Data from this study should be used to assess the appropriateness of current crane design wind speeds.

The hoist recommendation for engineering sign-off calls for a formal review of the ability of the building to support loads imposed by the hoist equipment.

C.7.2 Recommendation C-8: Tie-Ins

Tie-In connections should be subjected to special inspection and require improved design and erection procedures.

C.7.2.1 Description

Tie-ins are used with tower cranes that exceed the maximum freestanding tower heights set by the crane's Original Equipment Manufacturer (OEM). In such instances, the crane tower is usually attached to the building being constructed. The tie-ins transfer the lateral reaction forces of the tower crane to the building structure. Their placement, location and design are specific to each application and are prepared by the OEM or the Engineer of Record. Tie-in design, calculation and installation are approved by DOB as part of the "Certificate of On-Site Inspection" [CN].


Figure C.7.1: Examples of Tie-ins (Site C-10)

C.7.2.2 Recommendation Approach

Implementation of this recommendation should include the following actions:

- The connection at the building's floor slab should be subjected to Special Inspection for conformance with the approved drawings.
- If using friction connections, the crane Engineer of Record must specify the required bolt torque to providethe necessary clamping forces between the steel tie-in foot plate and the concrete slab are included in the design.
- If using a bearing connection, the crane Engineer of Record and the contractor should check that the bolt holes in the concrete have a close tolerance, and the bolts/threaded rods should be pre-tensioned. An alternative is the use of grout or steel bushings.
- Permitting of crane and hoist machines should require PE sign-off for loads imposed.

The connection at the building's floor slab should be subjected to Special Inspection for conformance with the approved drawings.

This inspection would include photographs showing the rebar-placement and documentation of the inspection in a log available to DOB. For installations that require higher-strength concrete at the tie-in locations than in adjacent regions of the floor slab, the contractor should supply test results, to the Special Inspector, verifying required concrete strength.

Tie-in design and installation are covered under Chapter 33 of the New York City Construction Code, and more specifically paragraph 3319.6 requires the equipment user, or his designated representative, to apply for and obtain a certificate of on-site inspection that DOB must approve prior to a crane arriving at site. DOB presently does not require Special Inspection of, or typically inspect, the tie-in locations prior to pouring concrete.

One occurrence was noted where the concrete design strength was higher than the installed strength. This was confirmed by the Crane EOR, and the EOR provided calculations that the lower installed strength was acceptable based upon the design criteria. If the original design was correct, the concrete may have failed. There was also an occurrence where the building EOR added rebar to the Crane EOR's design to overcome the bending moment on the concrete slab (site C-110 4/7/09). Figure C.7.2 shows the addition to the Crane's EOR drawings and the building EOR stamping the drawing.

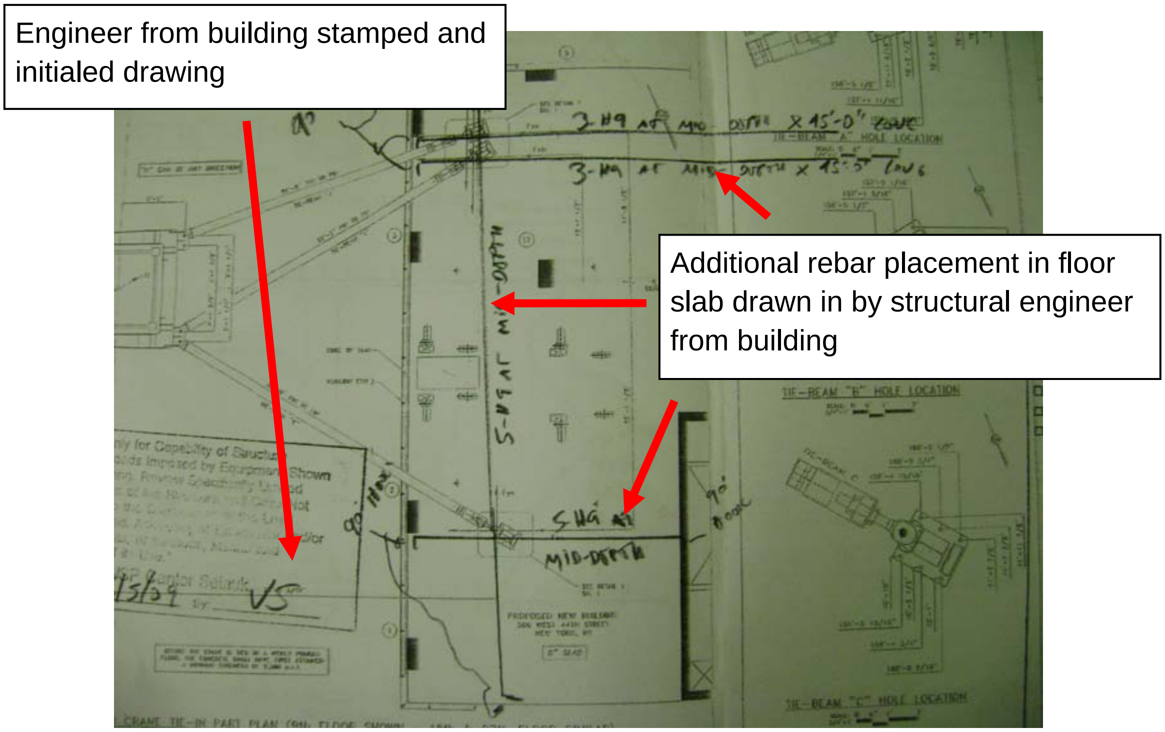


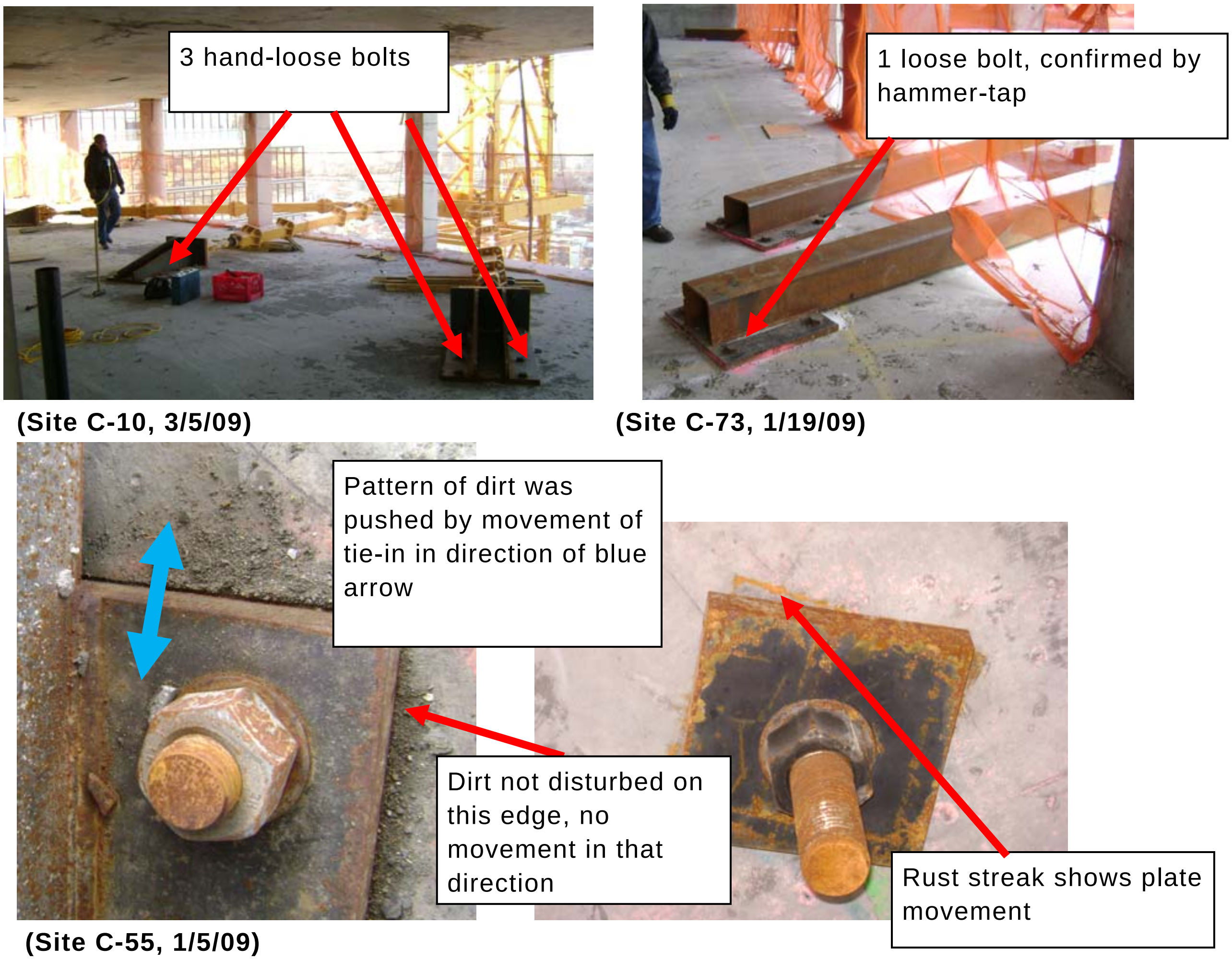
Figure C.7.2: Tie-in Slab Drawing Modifications (Site C-110)

If using friction connections, the crane Engineer of Record must specify the required bolt torque to provide the necessary clamping forces between the steel tie-in foot plate and the concrete slab are included in the design.

The crane user must provide a means to assure that the bolt connections remain properly torqued (e.g. periodic re-torquing of bolts). Re-torquing may need to be conducted on a weekly, or even shorter, basis. Documentation of the minimum bolt torque and re-torquing procedure must be kept on site and accessible to DOB. The HRCO crane team recommends that the EOR insert such on the drawings provided with the Certificate of On-Site Inspection (CN).

There are two primary professional engineering firms that submit applications for Certificates of On-Site Inspections for tower cranes. One prefers to design a friction connection and one a bearing connection. The friction connection relies on the clamping forces and smaller bolts to hold the tie-in strut in place during the crane's operation. The reason the user must check the bolt for looseness is that the steel will have a tendency to wear down the concrete.

The HRCO crane team found four (4) instances where there were loose bolt(s) on 3 friction connections, and one of these showed signs of tie-in movement (see Table C.7.1).



(Site C-10, 3/5/09) **(Site C-73, 1/19/09)**

(Site C-55, 1/5/09)

Figure C.7.3: Examples of loose friction tie-in strut connections

If using a bearing connection, the crane Engineer of Record and the contractor should check that the bolt holes in the concrete have a close tolerance. The bolts/threaded rods should be pre-tensioned. An alternative is the use of grout or steel bushings.

This is one of the preferred tie-ins designs submitted by the EOR's in New York City. The bearing connection uses larger bolts and relies on the allowable bearing pressure of the concrete.

The ability to check a bearing connection is limited to when the crane is dismantled. The HRCO crane team observed one instance of a bearing connection with loose bolts (see Table C.7.1).

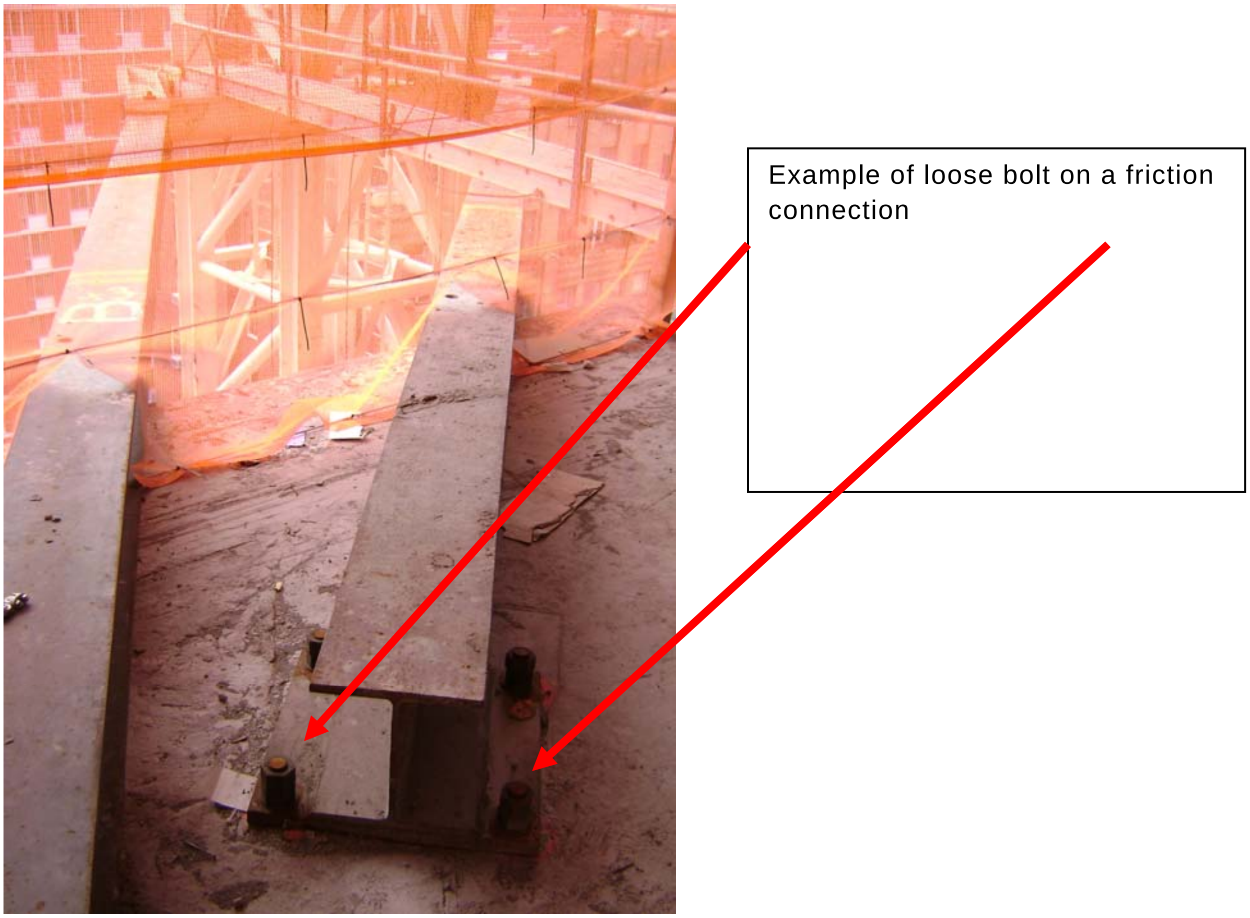


Figure C.7.4: Friction Connection Bolts (Site C-88 – 1/5/09)

Issue	Checked	Occurrence
Tie Installation Differed from the Original Design	2	2
Loose Connection Bolts on a Friction Connection (21 tie-ins on 11 cranes were checked)	21	4
No Building Engineer or Independent PE Sign-off on Loads Imposed.	14	10

Table C.7.1: Observations of Tie-In Connection Issues

Require the building engineer of record or an engineer acceptable to DOB to review the plans to determine the building can support the loads imposed by the crane.

The procedure would require the following to be submitted to DOB:

- Building structural information submitted by the building Engineer of Record with currently available information to support an analysis of loads imposed by the crane equipment (if available for existing buildings).
- An analysis of the loads imposed by the crane equipment (considering at a minimum, local resistance of reaction forces and lateral system analysis) by either the building Engineer of Record or by a licensed professional engineer acceptable to the Department of Buildings. The reviewer should document this by a signed shop-drawing stamp on a copy of the approved tie-in drawing**.**

DOB has examiners that review each application for compliance to the regulation and they check the calculations provided by the licensed engineer. The examiners require the crane licensed engineer to provide the calculations of forces created by the crane. Generally, the building engineer has not signed off or stamped the crane drawing indicating that the building and slab can withstand the forces.

A review of 14 open CN's showed only four contained such a letter or stamp from the building (or independent) engineer (see Table C.7.1). On one of these occurrences, the building EOR added rebar to overcome a bending moment in the slab (Site C110).

C.7.2.3 Additional Considerations for Good Practice

Climbing frames should be stored at all times in accordance with manufacturer recommendations (typically this is at the top tie-in). The Site Safety Manager or similar personnel should receive specialized training and tools allowing them to supervise loosening of tie-ins as required in case of a storm warning.

Presently, only a Master Rigger can supervise all aspects of the assembly, climbing or dismantling of a tower crane. The HRCO crane team observed one occurrence in which the plans lacked detailed information regarding the releasing of a tie-in.

Some site drawings prepared by the engineer of record require that in cases of an upcoming storm condition certain tie-ins must be loosened and/or the climbing frame lowered and secured at the top tie-in. In New York City, only a licensed master rigger and properly trained crew are allowed to perform these operations.

There may be, at any one time, at least 20 cranes requiring these storm preparations located within the jurisdiction. This could put extreme pressure on the limited number of licensed riggers that can prepare the cranes properly. The engineer of record should prepare the loosening procedure and provide training and instructions for specific tie-ins.

Tie-in installation should be done only when the crane is in a balanced position. This will assist in the event where a tie-in must be released and re-installed.

Installing ties while the crane is "balanced" (i.e. the crane is configured to minimize the overturning moment) minimizes the force in the tie. In this way, if the crane is returned to the balanced position when the tie needs to be released the unbolting process will be much easier. This is a particularly beneficial in case a tie must be released in an emergency situation such as a high wind alerts.

Require positive steel rope or steel structure support from the tie-in collar to the tower leg.

It is common practice to attach wire ropes from the tie-in collar to a mast section/leg as a safety should the primary collar attachment to the tower via shims, threaded friction pads or similar means come loose.

At two installations the safety sling for the tie-in collar was attached to a horizontal member (Figures C.7.5 and C.7.6). This introduces a bending moment on a tension or compression member that is normally not designed for bending.

If the tie-in collar is not close (as defined by the manufacturer) to a panel point on the tower section, the tower-legs should be reinforced or inner bracings installed in accordance to the manufacturer's recommendations.

Engineers of record typically design the crane installations with the tie-in collars at panel points or note that reinforcement of the mast section is required. This is a good practice that should be promoted (Figure C.7.7).

Safety slings attached to tower lacings

Figure C.7.5: Safety Slings at Site C-62.

Safety slings attached to tower lacings

Figure C.7.6: Safety Slings at Site C-73.

The circled beam is an example of inner-bracing near the collar

Figure C.7.7: Example of Tower Reinforcement at Tie-in (Site C-78, 10/9/08).

C.7.2.4 Additional HRCO Data

Several jurisdictions and national standards have regulations that specifically speak to verifying the appropriate loads for tie-ins. Table C.7.2 provides a summary of a few.

Standard or Jurisdiction	Covered Issue
ASME	Tie-in must be designed and anchored to the collar by a qualified person pursuant to the forces provided by the manufacturer
	A qualified person shall review the transference of the horizontal and vertical crane reactions to the building
	The concrete strength must be at design prior to climbing a crane
	A qualified person shall review the integrity of the host structure for the effects of crane, load, and wind forces at each level of the structure
	The user must check for looseness or preload for the connection after the first day and the first week of operation and then monthly
Construction Safety Association of Ontario	The shoring and bracing that support a tower crane or tie it in place shall be designed by a professional engineer in accordance with the crane manufacturer's specifications
	The structural engineer responsible for the structural integrity of the building or structure shall review the design drawings for the foundation … to ensure the structural integrity of the building or structure
C-DAC - OSHA	Prior to, and during, all climbing procedures, the employer shall: … (ii) Have a registered professional engineer verify that the host structure is strong enough to sustain the forces imposed through the braces, brace anchorages and supporting floors
	The following additional items shall be included (inspected): (ii) The upper-most tie-in, braces, floor supports and floor wedges where the tower crane is supported by the structure, for loose or dislodged components
Health and Safety Executive - Britain	A report prepared by appointed person that planned and supervised the erection of the tower crane. The report should include: • Tie loadings; • Confirmation from the building designer (Structural Engineer) that tie loadings to be imposed on the building can be absorbed by the building structure; • Confirmation that the tie design, type and fixing method is sufficient for the anticipated tie loadings; • Confirmation that the ties have been correctly assembled positioned and adjusted.
Hong Kong	Requires that the structural design of the building is the responsibility of a Registered Structural Engineer. This includes that all anchorage points be designed to withstand maximum loads that the crane may exert in the most severe static and dynamic conditions.

Table C.7.2: Summary of Other Jurisdiction and Standards Related to Tie-ins

C.7.3 Recommendation C-9: Foundations

Foundations should be subjected to special inspection and require improved design and erection procedures.

C.7.3.1 Description

Concrete foundations for tower cranes are typically poured together with the building's foundation, and prior to the application for the Certificate of on-site Inspection (CN). This results in the foundation being installed without notifying DOB or providing DOB the opportunity to inspect the installed anchor stools and rebar mat to ensure they are in compliance with the approved drawing(s). At present, there is also no formal provision for Special Inspection of the foundation system.

The industry typically uses a template to align the anchor stools. A non-rigid or insufficiently fastened template may shift during the pour. If this occurs the contractor will need to elongate the bolt holes and/or shim the anchor stools to mount the first tower section.

Figure C.7.8: Tower Crane Foundation (Site C-3, 9/5/08)

C.7.3.2 Recommendation Approach

Implementation of this recommendation should include the following actions:

- The Crane Engineer of Record (EOR) should submit foundation plans to DOB prior to pouring; and in addition to structural details of the foundation anchorage, the plans should identify any issues and conflicts with known site conditions
- Require Special Inspection before the foundation pour to confirm conformance with design drawings. To facilitate this, the crane user should notify DOB at least 48 hours prior to the foundation pour to provide opportunity for DOB to audit the installed condition.
- Allow the crane installation contractor to use an actual tower mast section to assist with the alignment of the anchor stools by casting the stools into the foundation while attached to the section. If a template is used, it must satisfy ANSI B30.3 requirements. If a mast section is used, the Contractor should request DOB to perform a pre-assembly inspection for the installed section.
- The crane user should install Original Equipment Manufacturer anchor stools whenever available.

The Crane Engineer of Record (EOR) should submit foundation plans to DOB prior to pouring; and in addition to structural details of the foundation anchorage, the plans should identify any issues and conflicts with known site conditions.

The typical foundation design and construction process (particularly for crane foundations that fall within the foot print of the new building) involves the following:

- The tower crane foundation is designed by the crane Engineer of Record (EOR) and constructed in conjunction with the building foundation.
- The process typically occurs weeks or months in advance of selecting a specific tower crane make and model.
- The EOR designs the crane foundation to accommodate the worst-case loads from probable crane models.
- Adapters are used, as necessary, to mate the final crane selection to the existing foundation.

  Once the contractor decides on a particular type of crane, he applies for a Certificate of On-Site Inspection sending plans and calculations of the foundation to DOB. As identified above, DOB reviews the plans for the foundation as part of the certification process.

The HRCO team noted instances where the foundation was poured prior to the CN submittal. NYC crane industry representatives confirmed in DOB industry meetings, that this is commonplace.

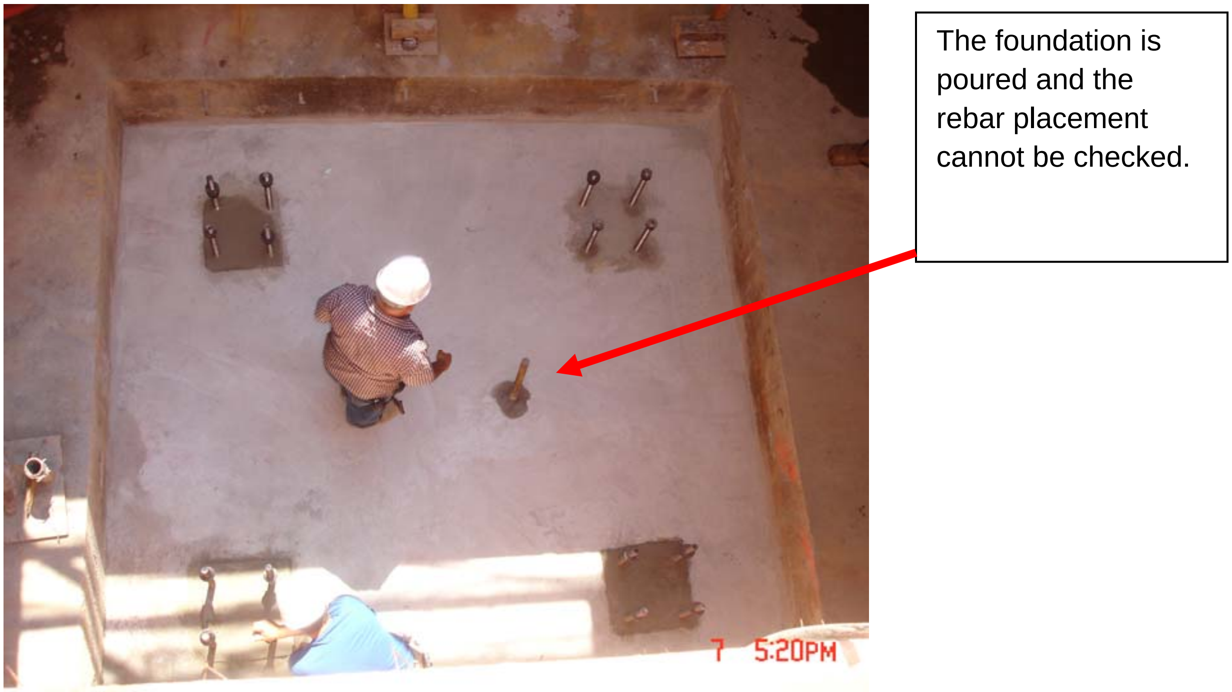


Figure C.7.9: Poured Foundation (Site C-78, 8/7/08)

On one occasion, the foundation was poured while the plan examiners were reviewing the application. In this instance, the contractor attempted to epoxy dowels in concrete just 2 days after it was poured without consulting the epoxy manufacturer. DOB discovered this due to an inspector being on-site for another reason and stopped the job until the epoxy manufacturer was consulted (Site C-78).

Foundation design and eventual installation are covered under Chapter 33 of the New York City Construction Code, and more specifically paragraph 3319.6 requires the equipment user, or his designated representative, to apply for and obtain a Certificate of On-site Inspection that DOB must approve prior to a crane arriving at site.

In order to better ensure that the established technical requirements are being followed, the Department should require a Special Inspection before the foundation pour to confirm conformance with design drawings. To facilitate this, the crane user should notify DOB at least 48 hours prior to the foundation pour to provide opportunity for DOB to audit the installed condition.

Special Inspections have not been required. However, the industry has performed some at their own discretion. Proper crane foundation construction is critical for the support of the crane, particularly the initial period of use when the crane is free-standing. Special inspection is clearly warranted to provide assurance of proper construction.

Allow the crane installation contractor to use an actual tower mast section to assist with the alignment of the anchor stools by casting the stools into the foundation while attached to the section.

If a template is used, it must satisfy ANSI B30.3 rigidity requirements. If a mast section is used, the Contractor should request DOB to perform a pre-assembly inspection for the installed section.

DOB does not currently allow the contractor to use a tower section until the CN is approved. DOB deems a tower section as a partial "tower crane erection". For this reason, the industry defaults to using templates. Previously, DOB authorized the contractors to use the first section as a template. It is the HRCO understanding that DOB is working to amend this restriction and allow a section to be used as outlined above.

The HRCO team witnessed instances where the installation team had to use shims and/or enlarge the bolt holes to attach the first section to the anchor stools. This practice places an additional bending moment on the bolted connection. The use of the first section will allow the installation team to plumb the tower prior to pouring the foundation, which will minimize the need to shim and enlarge bolt holes. Figure C.7.10 shows an anchor stool and tower section that illustrates the need to shim the tower to achieve plumbness.

The HRCO team observed one contractor that used half of a tower section as a template and one that made one from a non-rigid material (½" plywood) (site C-89 – 10/17/08).

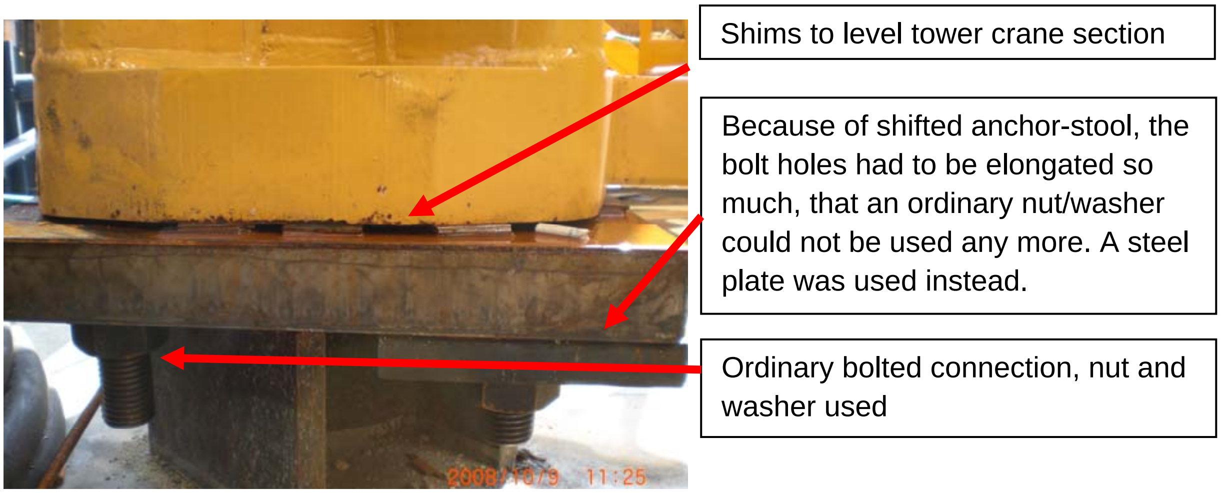
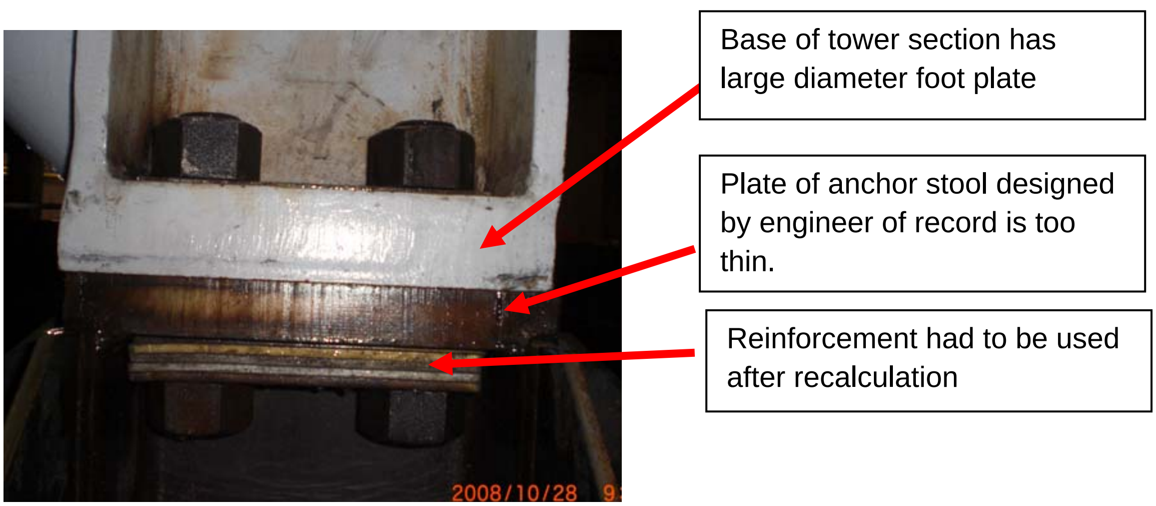


Figure C.7.10: Site C-55 – 10/9/08, examples of excessive shimming and bolt-hole elongation probably shifted.

The crane user should install Original Equipment Manufacturer anchor stools whenever available.

The practices in NYC are that the crane owner or user installs an anchor stool of their choice, and the licensed crane engineer designs anchor stools for particular cranes.

One custom (non-OEM) anchor stool was under-designed by the Crane Engineer of Record and required reinforcement prior to the crane being assembled.



(Figure C.7.11: Site C-89 – 10/28/08, under designed anchor stool)

C.7.3.3 Additional Considerations for Good Practice

The practice of designing a foundation prior to selection of a specific crane make, model and configuration leads to situations where special adapters must be designed to mate incompatible anchors and tower legs. It also creates the possibility for foundation design error (i.e., inaccurate and/or insufficient loads). The industry should move to a system in which the foundation is designed specifically for the crane that is actually used.

C.7.3.4 Additional HRCO Data

Several jurisdictions and national standards have regulations that specifically address verification of the appropriate loads for foundations. For example:

ASME B30.3-2004 Construction Tower Cranes recommends that the first tower mast section be used and be secured before the concrete foundation is poured. If this cannot be done, the standard requires a template to be rigid and built so that the tower leg bearing surfaces are in the same plane.

C-DAC - OSHA The proposed OSHA rules in C-DAC, include the following:

$1926.1435 Tower Cranes

"(b) Erecting Climbing and Dismantling
(3) Foundations and structural supports. Tower crane foundations and structural supports shall be designed by the manufacturer or a registered professional engineer.

(4) Addressing specific hazards … In addition, the Assembly/Disassembly (A/D) supervisor shall address the following: (i) Foundations and structural supports. The A/D supervisor shall verify that tower crane foundations and structural supports are installed in accordance with their design."

Singapore requires new foundation anchors each time a tower crane is assembled. Further, the Ministry of Manpower circular OSHD / LE 1/08 implies that the foundation is inspection prior to the pouring of concrete;

Britain Uses an approach, where the HSE (Health and Safety Executive) similar to the American OSHA decided, that tower cranes have to be erected by the crane owner, who hands the erected crane over to the crane hirer. The crane hirer normally provides the tower crane foundation. Internal documents are used to assure the quality of the foundation. The HSE approved publication "Safe Use of Top Slew Tower Cranes" describes the procedure and shows an example:

“*This loading information should be used by the foundation designer employed by the user, to produce an adequate design, taking into account the ground conditions on site. Wherever a concrete pad, steel grillage, piled foundation or rail track is constructed to accept the loads from a TSTC, the contractor constructing the foundation should complete a foundation completion form to certify that the foundation has been correctly designed and constructed before erection of the crane starts.*”

Tower Crane Foundation Approval/Completion Certificate

Site Details :

Crane Details

Make:		Model:	
Height under Hook:		Jib Length:	
Base Type:			

Foundation/Grillage Design

Document and Drawing References:

Design Carried Out By:

Company:

Foundation/Grillage Design Approval

Design Approved By:

Signature:	Date:

NOTE: A separate approval/completion certificate is required for each tower crane

Permit To Erect

I confirm the tower crane foundation has been constructed to the specifications detailed above, the foundation anchors/base pads are level and plumb as specified, and that the tower crane may be erected.

Signature:	Date:
Name:	Position:

NOTE: The tower crane cannot be erected until the completed form is returned to the Operations Department

Figure C.7.12: UK Certificate

The British Health and Safety Executive (HSE) approved publication “Maintenance Inspection and Thorough Examination of Tower Cranes; a Best Practice Guide” gives further information regarding the foundation inspection in section A11.12 (Foundation As–Built Report).

This report confirms that the foundations have been constructed in accordance with the foundation design (see summary in Table C.7.3). The report should be prepared by the organization that has constructed / installed the foundation. The appointed person responsible for the planning and supervision of the crane erection should countersign the report.

All Foundations	• Report confirming the foundation is in accordance with the foundation designer's drawings. • Measurements confirming dimensional accuracy and level.
Cast-in Items	• Level, plumb and to tolerance.
Reinforced Concrete	• Record of concrete mix and placement date, cube tests were carried out, to ensure concrete is of the correct grade and sufficient maturity.
Piles	• Results of pile tests. • Confirmation that the design has sufficient reinforcement bond length into pile cap and that the pile to take tension where applicable.
Steelwork	• Steel dimensionally correct and to the correct grade. • Bolts to the correct grade and tightened to specified torque. • Weld quality (NDT results if required).
Rails	• Bedding properly compacted. • Sleepers of sound quality and rail clips securely fastened. • Rail centres and levels to correct tolerances. • Limit ramps and end stops correctly positioned and firmly fixed. • Rails earthed.

Table C.7.3: Summary of the UK Foundation As-Built Report.

New Zealand states the following requirements in the "Approved code of practice for cranes" published by the Department of Labour:

"10.2 (6) Part 2: The inspection and testing of the tower crane after erection and annual inspection for recertification.

Inspections and testing will cover (but are not limited to) the following items. The following documentation is to be provided by the controller to the equipment inspector prior to testing commencing:

(b) Foundation certificate, covering design and construction, from a chartered professional engineer and crack testing results of base anchors. IANZ-endorsed NDT reports are required."

C.7.4 Recommendation C-15: Load Test

The test weights to be used should not exceed the manufacturer's specification or, in case where the manufacturer is not available, the applicable ANSI standard should be followed..

C.7.4.1 Description

A load test is part of DOB crane inspections (required by RS 19-2) for tower cranes. The test verifies that the crane, generally, is able to lift and hold the maximum rated load at the corresponding radii. Further, the installed safety devices warn the crane operator about a maximum load situation and eventually stop the lifting, booming, lowering and/or trolley out motions. The Engineer of Record for the Certificate of on-site inspection (CN) provides the load test procedure with eachapplication.

Figure C.7.13: Load Test in Operation

In two cases a test load of the exact weight was not available on site, and the engineer of record provided a test procedure where the crane would have attempted to lift a test load exceeding the maximum allowable weight. In case of a malfunction of the safety devices that are to be tested, the crane could have been overloaded. In extreme cases this could cause catastrophic crane failure. In other cases, structural components and parts of the hoisting apparatus of the crane could have been overstressed, causing deformation, cracking or general weakening of crane components. These defects are often hidden and could heighten the risk of a catastrophic failure at a later date. In 2008, there was an incident that a crane dropped a load during a load test.

C.7.4.2 Recommendation Approach

The Engineer of Record should include manufacturer recommendations or ANSI information when providing the load test procedure in the Certificate of on-site inspection (CN). In addition, the procedure should include:

- Line pull test should be performed on all gears
- A moment test should be performed as a standard practice for all load tests.
- All limit and pre-limit switches should be tested during the load test.

Inspectors from DOB witness all tower crane load tests. However, DOB has allowed procedures that could have overloaded the crane based upon the EOR's procedures included in the CN.

The HRCO moderated a conference of major crane manufacturers in November 2008. The manufacturers unanimously confirmed that load tests should be conducted with a test weight limited to the proper test load and that the crane should not be placed in a situation whereby it may become over-loaded. Similarly, ANSI standards B30.3 and B30.5 regarding load test states that the weight should not exceed 110% of the rated load.

Load test procedures submitted by engineers of record on C/N applications have created situations where the crane could have been overloaded as shown in Table 7-4. Further, load test procedures submitted by engineers of record for C/N application and reviewed by the HRCO team were contrary to the manufacturer's recommendation and the ANSI B30.3 standards by designing a protocol that the crane could have attempted to lift a weight 130% over the rate load should the safety features fail.

In three instances, the EOR did not include a moment over-load test. Cranes typically have two controlling load cases, maximum load and maximum moment. Both controlling cases must be checked to confirm the safety of the crane. Checking just one does not confirm whether the crane can safely operate under the other condition.

Reference Standards 19-2 (Paragraph 13.1) (dated September 14, 2006) requires that load ratings for climber tower cranes be conducted so that no structural member is overstressed.

Issue	CN's Checked	Occurrences
Crane could have lifted more than 110%	13	5
Procedures on CN's that did not have a moment test	13	3
Procedure did not include a line pull on all gears	13	2

Table E.7.4: Review of Submitted Load Test Procedures

C.7.4.3 Additional HRCO Observations

The primary focus on the benchmarking activity on this recommendation was on standards published in the United States. Two such standards were developed by the American Society of Mechanical Engineers (B30.3 and B30.5). The tower crane standard (B30.3) primarily recommends that after erection (and climbing operations) all functional motion, limiting devices and brakes be tested prior to the operation. The static test load should be in the range of 102.5% to 110%, as recommended by the manufacturer. The Mobile crane standard (B30.5) requires a load test prior to the initial use or if load sustaining parts have been altered, replaced or repaired. The load test weight shall not exceed 110% of manufacturer's load rating.

In addition, manufacturers do not allow over loading the crane. Below is a portion of a load test procedure outlined in an OEM's operating manual.

"Set the switch OS 11 "Hoist up": Attach the test load (minimum: permissible load at the end of the jib; maximum: permissible load at the end of the jib ***+10****%).*

*Set the switch OS 12 "Trolley forward*__**":**__ *Attach the test load (minimum: maximum permissible load; maximum: maximum permissible load +****10****%)."*

C.7.5 Recommendation C-5: Counterweights

Counterweight information should be readily available on the drawing and on the counterweight module itself.

C.7.5.1 Description

Most tower cranes and larger mobile cranes rely on counterweights to provide stability. The complete counterweight is typically assembled from several counter weight modules. An error in the counterweight configuration or a malfunction of the mechanism that actuates movable counterweights can have catastrophic results. In addition, damaged concrete weights can present debris fall hazards.

Figure C. 7.14: Crane counter weights

C.7.5.2 Recommendation Approach

Implementation of this recommendation should include the following actions:

- Require a clear description of the value and configuration of counterweight on the overview-drawing of the Certification of on-site Inspection (CN) submittal.
- Require each counterweight module to be labeled in a way that clearly and conveniently identifies the weight, including the assembled state (e.g. labels or stenciled number on the sides).
- Pay special attention to signs of corrosion and poor maintenance on the movable counterweight mechanisms.
- Enclose concrete counterweights to protect against damage and spalling.

Require a clear description of the value and configuration of counterweight on the overview drawing of the Certification of on-site Inspection (CN) submittal.

DOB does not require the Engineer of Record to include the counterweight configuration in the CN. However, details of other components are required such as height of tower and length of boom.

The HRCO observations shown in Table 7-5 identify that none of the reviewed CN's contained counterweight information. This is not unexpected since this is not a requirement. However, every project must have the CN plans on site and as such this would be the appropriate place for DOB, or special inspector, to review the information. Also, Figure C. 7.14 shows the location of various counter weights for two different cranes. The one on the left has markings and the one on the right has only one module labeled.

Require each counterweight module to be labeled in a way that clearly and conveniently identifies the weight, including the assembled state (e.g. labels or stenciled number on the sides).

Current regulations do not require the counterweight value of each module be in a visible location. Further, DOB inspectors typically do not have the information to audit the installed counterweight configuration. Based on HRCO observations, the industry does not generally mark all counter weights in such a fashion that an Inspector can verify the designed configuration (weight and location). One out of the fifteen counterweight configuration has all modules marked in a visible manner (Figure C.7.14).

Table 7-5 provides data that indicate that the industry has not marked the counterweights in such a fashion that an Inspector can verify correct configurations (weight and location).

Observation Type	Number of Observations	Observations with Issue
CN's reviewed that did not have counter weight configurations	20	20
Counter weights without markings visible on all weights	15	14
Movable counter weight mechanism requiring maintenance	34	5

Table C.7.5: Counter Weight Issues

Pay special attention to signs of corrosion and poor maintenance on the movable counterweight mechanisms.

Of the 34 tower cranes visited, five showed signs that the movable counter weight mechanism required some type of maintenance (i.e., excessive rust, rope required lubrication, etc.)

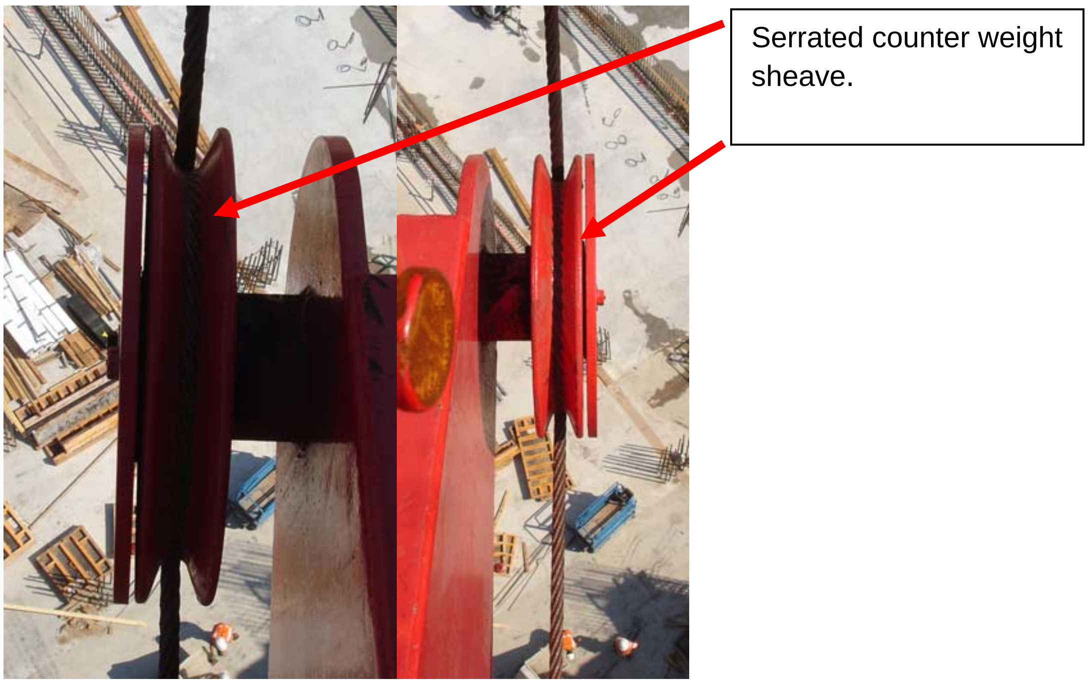


Figure C.7.15: Serrated Counter Weight Sheaves (Site C-22, 9/4/08)

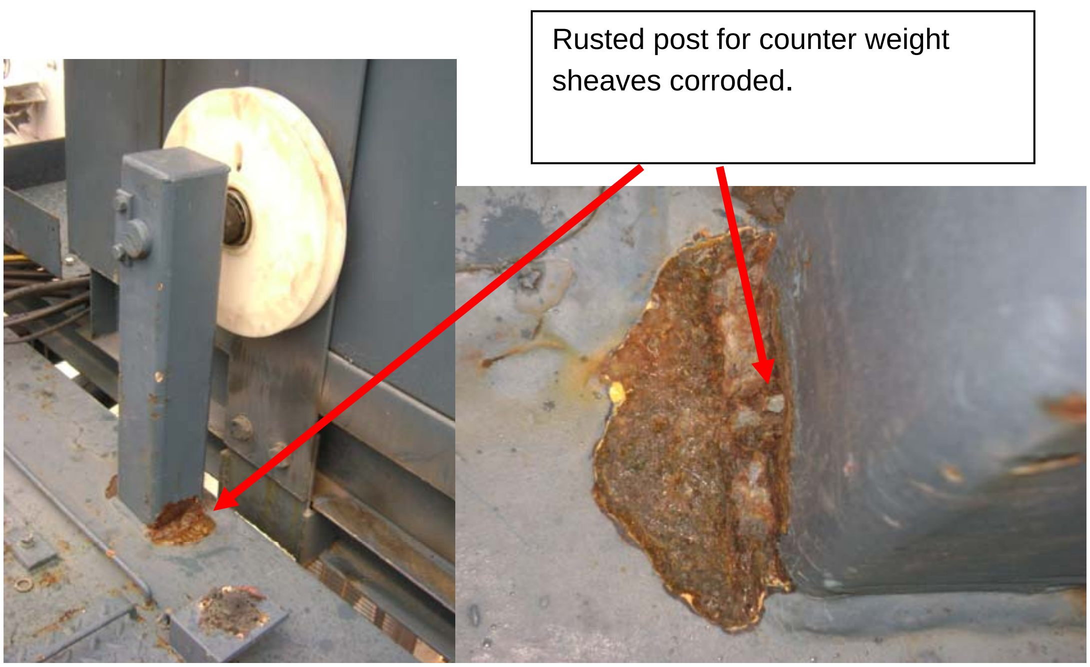


Figure C.7.16: Rusted Counter Weight Sheave Posts (Site C-61, 11/5/08)

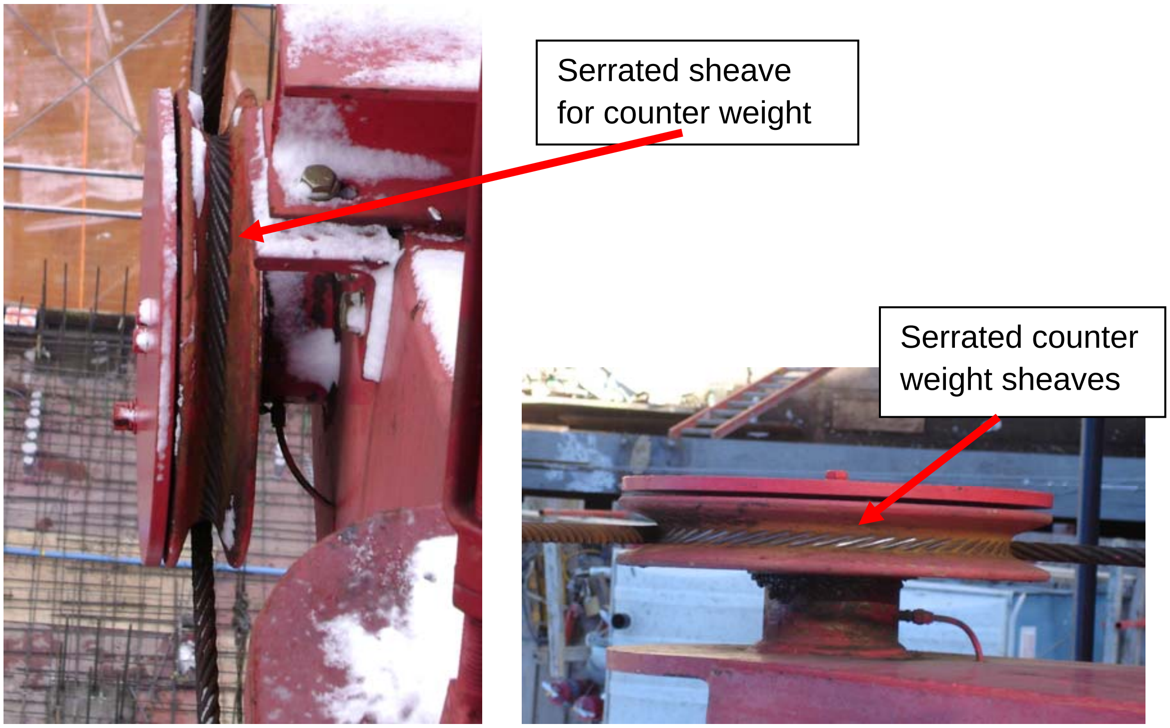


Figure C.7.17: Counter Weight Sheaves (Sites C-73 and C-76)

Enclose concrete counterweights to protect against damage and spalling.

The use on non-framed hanging concrete counter weights is limited in New York City. Hanging concrete counterweights deteriorate over time, and become cracked and/or damaged during handling, which could result in failure or spalling (see Figure C.7.18 from site C-6 – 7/3/08).

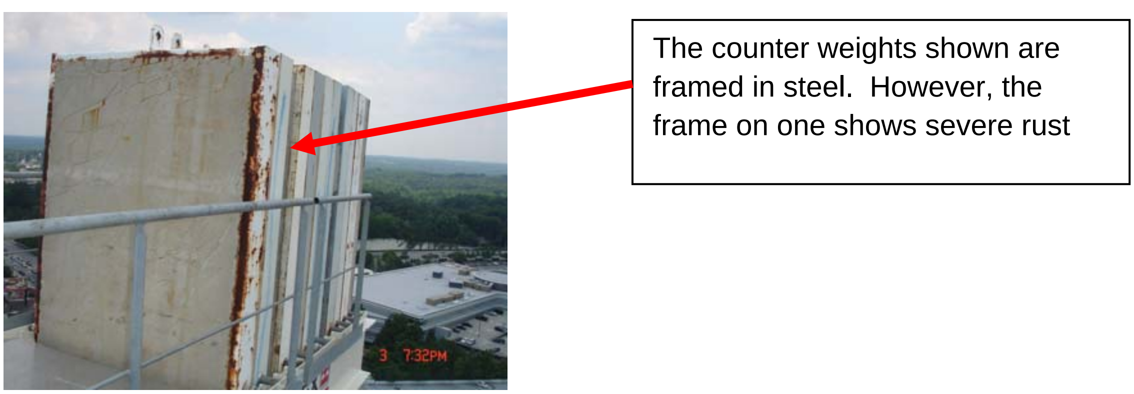


Figure C.7.18: Encased Concrete Counterweights

C.7.5.3 Additional HRCO Data

ASME and C-DAC contain provisions directly related to the counterweight recommendation:

ASME B30.3 – 2004

Construction Tower Cranes provides that the counter weight arrangement be pursuant to the manufacturer's specification and be guarded against shifting. The counter weight movement ropes should be inspected monthly, if one is provided.

C-DAC

The proposed new C-DAC rules include:

> **§1926. 1435 Tower Cranes**
>
> ***"(b) Erecting Climbing and Dismantling***
>
> *(8) Counterweight / Ballast*
> *(i) Equipment shall not be erected, dismantled or operated without the amount and position of counterweight and/or ballast in place as specified by the manufacturer or a professional engineer familiar with the equipment.*
>
> *(ii) The maximum counterweight or ballast approved by the manufacturer or professional engineer familiar with the equipment shall not be exceeded."*

The Committee also considered whether an operational aid in the form of counter weight sensors should be required on all equipment manufactured after January 1, 2008. Several Committee members representing crane manufacturers expressed concern as to the difficulty in developing a reliable counterweight sensor presently or in the near future. In light of these technological problems, the Committee did not include these.

C.7.6 Crane Design for Wind Effects

This is not a formal recommendation, in that there is no indication that the current wind design basis of cranes in NYC is deficient. However, various countries are researching and considering revising their wind calculation requirements for temporary structures. This includes how wind affects tower and large mobile cranes. There are differences between US and European approaches to the development of wind forces on crane members. In addition, and as would be expected, the HRCO crane team observed that the older cranes were designed using an older wind standard (ANSI/ASCE 7-98), others by the newer standard (ANSI/ASCE 7-05), and some models used a combination of standards. A further study to determine the applicability of these standards should be considered.

A related HRCO recommendation for high-rise concrete construction indentifies the need for increased monitoring of actual wind speeds in Manhattan. Data from such monitoring should be used to assess the appropriateness of current crane design wind speeds.

C.7.7 Hoist Recommendation H-2: PE Sign-Off

Require the building engineer of record or an engineer acceptable to DOB to review that the building can support the loads imposed by the hoist.

C.7.7.1 Description

There is no current requirement that a structural engineer review and sign-off on the applied building loads, nor is there a formal DOB engineering permitting review process. Consequently permits are approved by DOB and awarded to the contractor without engineering review of the hoist design, including the attachment to the building.

In most cases the Hoist Contractor does note directly on the drawings that the structure is “to be” or “must be” reviewed or evaluated by others. However, in most cases (73%) the HRCO hoist team has not been able to identify confirmation of any type of such review. Of the drawings that were available for review, most lacked sufficient information necessary for a proper review (particularly the loads imposed on the building structure by the hoist).

For those cases where a review was called for but not executed may be attributable to a number of causes. First, it informally appears that once the hoist drawings are prepared they are hastily submitted for permitting. Other cases may be attributed to the lack of judgment on the GC’s part. Non-PE project managers may fail to properly value the importance of this review; because it can save money as well as potentially avoid a delay they decide to opt out of the review.

For the 27% of sites where the GC did provide proof of a review it was typically the result of due diligence by the General Contractor or their Project Manager. In these cases we’ve found that either the project manager was a Professional Engineer, the GC was unusually prudent or there was some discernible feature of the design warranting such a review. A discernible feature may be that the hoist or its supporting structure is bearing on a temporary structure or shoring, or some kind of cantilever part of the building. .

Three sites visited by the HRCO hoist team required additional shoring for supporting structure. This deficiency would likely have been identified during an engineering review.