Descriptive Statistical Analysis of OSHPD Quality Inspections on California Hospital Projects

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California hospital construction projects are large, complex, and extremely difficult projects to execute and navigate successfully. One of the primary reasons for this is the OSHPD permit, review, and inspection process. The quality control rigor imposed by this third party inspection procedure has caused great angst amongst most general contractors and subcontractors. This study examined over 60,000 OSHPD inspections, spanning six California hospital projects and forty-one separate subcontractors. Specifically, this paper conducts descriptive statistical analysis on the total number of inspections conducted and the percentage of failed inspections (or re-inspections) that occurred. The analysis, conducted on major subcontractors working on significant California hospital construction projects, revealed that on average nearly 1500 inspections per subcontractor per project were conducted with an average overall re-inspection or failure rate of just over 9%. This is a directly measurable input to the cost of quality or rework. Benchmarking analysis was also conducted revealing that for all major subcontractors a best inspection failure performance of 2.02% was achieved and worst of 21.82% was observed. These kind of statistics are noteworthy as they are measurable data which could be applied to future projects and assist in decreasing inspection failures and the cost of quality.

Key Words: Quality, Subcontractors, Hospital Construction, Inspection Failures, Benchmarking

Introduction

It is well established that "the project cost, quality, safety, and duration are core elements that contribute to project success" (Wanberg, Harper, Hallowell & Ragendran, 2013, p.1). Three of these elements are fairly well understood, measurable, and clearly definable, but the term "quality" has continued to be treated with some ambiguity. The construction industry has always struggled with the term quality, partially because of an inability to properly define it (Love & Edwards, 2004). Quality is often related to characteristics or a degree of excellence or goodness. From this it can be presumed that "high quality" goes hand-in-hand with high material costs, esthetically pleasing design, or a high degree of functionality. But these are nebulous and subjective concepts, not easily quantifiable and dependent on the person's point of view. Quality defined this way is mostly controlled by the design team and not the general contractor, who typically bids the job after the project design was completed.

Quality control (QC) is the consensus term for a construction inspection process which verifies the quality of construction projects. Crosby (1980) defined quality succinctly as the "conformance to established requirements". If construction quality fails to meet the established criteria, applicable codes and contract document requirements, then additional resources must be spent (or wasted) on quality costs. Failed third-party inspections and the resulting direct cost of rework, termed deviations, has been one cause of unnecessary construction cost attributed to lack of quality or cost of quality (Love & Edwards, 2004). Alfeld (1988) advances the view that construction, due to its magnitude alone, promises a greater payback for performance improvement than almost any other industry. A small improvement in quality performance during the construction process could translate into billions of dollars of cost savings for the industry.

The purpose of this paper was to analyze a specific sampling of data which measured the actual quality performance (inspection success) of major subcontractors on large California hospital projects. This data was examined to help better understand the quantity of inspections a subcontractor could expect on future projects, the percentage of failed inspections which might occur, and develop benchmark data used to measure a subcontractor's level of inspection success against other subcontractors and projects.

Subcontractor

A subcontractor is a construction firm that "contracts with a prime contractor to perform some aspect of the prime contractor's work" (Clough, Sears, and Sears, 2005, p.4). A large portion of the physical and billed work on most commercial construction projects (including hospital projects) is performed and accounted for by subcontractors (Hinze &Tracey, 1994). On commercial construction projects, general contractors have typically subcontracted to specialty subcontractors as much as 75% to 100% of the work (Schaufelberger & Holm, 2002). Because these specialty contractors have executed most of the tasks involved with a construction project, they have a significant impact on the project's success or failure (Schaufelberger & Holm, 2002).

Despite this fact the "issues concerning subcontracting practice are seldom acknowledged and the ways to improve subcontracting practice are seldom discussed." "Little research has been conducted and little information is published on this topic" (Arditi & Chotibhongs, 2005, p. 866). More efficient subcontracting (increased inspection success and reduced rework) would benefit all parties involved in the construction process including the general contractor, the owner, and the subcontractor (Arditi & Chotibhongs, 2005). Methods should be put in place which improve the chances of subcontractor success by ensuring that all aspects vital to a subcontractor go well (Boynton & Zmud, 1984).

Hospital Construction

The "Sylmar" earthquake in 1971 caused severe damage across southern California. It destroyed two hospitals causing the death of over 50 people. This event led to the passage of the Alfred E. Alquist Hospital Seismic Safety Act in 1973, which in turn led to the creation of the Office of Statewide Health Planning and Development (OSHPD) in 1978. All California hospital construction projects are subject to a separate design review and construction inspection process performed by the Facilities Development Division (FDD) of OSHPD. The FDD conducts plan reviews, issues building permits, confirms seismic compliance, performs construction inspections, and interprets regulations, building codes, and policies (OSHPD, 2013). Because of these regulations, hospital construction projects in California are highly scrutinized and are a rigorous ordeal for general contractors and subcontractors engaged in this building process.

Hospital construction costs have continued to increase even through the "great recession" of 2008 and 2009. From 2007 to 2008 alone, health care construction costs rose in all sectors of the health care construction industry; 2-3 story hospital project costs rose over 3% over that time (Carpenter, 2008). Jim Lott, executive vice president and spokesman for the Hospital Association of Southern California trade group, confirms the cost for building and rebuilding hospitals by "the state deadlines are causing all this construction to take place around the same time, which is causing a lot of challenges" and costs continue to go up (Crowe, 2008, p.4). In 2013 the square foot cost for health care facilities was over $400 per square foot according to R.S. Means (2013) a national construction cost estimating service. Other sources put it well above $450 per square foot. The need for an increase in quality and a corresponding decrease in schedule delays and cost overruns is vitally important to the California health care industry.

Research Methodology

This study mined existing third-party construction quality inspection data from the FDD through a proprietary inspection process tracking software. The intent was to document inspection success and failures on hospital construction projects in California at a subcontractor level. Existing data was extracted from the proprietary software and downloaded into MS Excel spreadsheets for further sorting and analysis. This data was gathered remotely and after-the-fact thus eliminating any form of bias and avoiding the Hawthorn effect. Three sets of data were discernable:

- Total number of inspections conducted per subcontractor.
- Total number of re-inspections (or failed inspections) per subcontractor.
- Total number of inspections and re-inspections per subcontractor over a common timeline.

The continuity of the data was validated by extracting data from six separate hospital projects, constructed in California, and all under the review and supervision of OSHPD. The construction projects were all completed between 2009 and 2014, varied in total construction cost between $260 million and $550 million, and ranged in total square footage of 300,000 to 650,000 square feet. No further information about the projects was provided in this paper to keep the identity of the projects and the project teams anonymous.

In all, OSHPD quality control inspection data was obtained and analyzed from forty-one (41) different subcontractors spanning the six different California hospital construction projects described above. See figure 1 for a breakdown of the forty-one subcontractors by trade, number in each trade, and designation reference number.

Framing & Drywall (7 each); FD1, FD2, FD3, FD4. FD5, FD6, FD7*

Electrical (6 each); EL1, EL2, EL3, EL4, EL5, EL6

Structural Concrete (5 each); SC1, SC2, SC3, SC4, SC5

Wet Mechanical (5 each); WM1, WM2, WM3, WM4, WM5

Fire Sprinklers (5 each); FP1, FP2, FP3, FP4, FP5

Dry Mechanical (4 each); DM1, DM2, DM3, DM4

Ceiling Panels (3 each); CP1, CP2, CP3

Insulation (2 each); IN1, IN2

Fire Stopping (2 each); FS1, FS2

Exterior Framing (1 each); EF1

Glass & Glazing (1 each); GG1

* FD7 exists because one of the six hospital projects used two framing and drywall subcontractors due to the size of the contract.

Figure 1: Subcontractors by trade, number (each), and designation

In order for an individual subcontractor on a project to be recognized as significant and used for this study, a minimum of 150 inspections conducted by OSHPD was established. Subcontractors who had less than 150 inspections were dismissed due to an insufficient number of data points. See figure 2 for a breakdown of the forty-one subcontractors selected, the hospital projects they worked, and the number of inspections conducted.

Hospital 1	
1. FD1	1536
2. FD2	771
3. EL1	1023
4. SC1	571
5. WM1	1002
6. FP1	269
7. DM1	835
8. CP1	262
9. IN1	190
Subtotal	6462

Hospital 2	
10. FD3	3775
11. EL2	5196
12. SC2	462
13. WM2	2406
14. FP2	429
15. DM2	2011
16. CP2	452
17. GG1	340
18. FS1	1503
19. EF1	1069
Subtotal	17643

Hospital 3	
20. FD4	3390
21. EL3	3320
22. SC3	343
23. FP3	519
24. DM3	1049
25. CP3	241
26. IN2	1152
Subtotal	10014

Hospital 4	
27. FD5	4904
28. EL4	1819
29. WM3	1658
30. FP4	265
31. DM4	525
32. FS2	1886
Subtotal	11057

Hospital 5	
33. FD6	2622
34. EL5	378
35. SC4	772
36. WM4	1988
37. FP5	197
Subtotal	5957

Hospital 6	
38. FD7	4252
39. EL6	2138
40. SC5	1745
41. WM5	1802
Subtotal	9937
TOTAL	61,070

Figure 2: Subcontractors by project, designation, and number of inspections

Data Analysis and Results

Three categories of descriptive statistics were conducted with the data obtained from the proprietary inspection tracking software:

1. The total number of inspections conducted for each subcontractor.
2. The total number of re-inspections (or failed inspections) and when in the project they occurred.
3. Benchmarking analysis.

Total Number of Inspections

A total of 61,070 OSHPD inspections occurred over the six hospital construction projects and the 41 subcontractors identified above. An average of 1,490 inspections were conducted per subcontractor per project. Major subcontractors on significant California hospital projects could generally expect nearly 1,500 inspections to occur on any particular project. This piece of data is probably not particularly useful knowing that the average number of inspections required for any particular trade would vary greatly. While more data points are desired, a particular subcontractor could benefit from figure 3 which identified the mean number of inspections required of a particular trade.

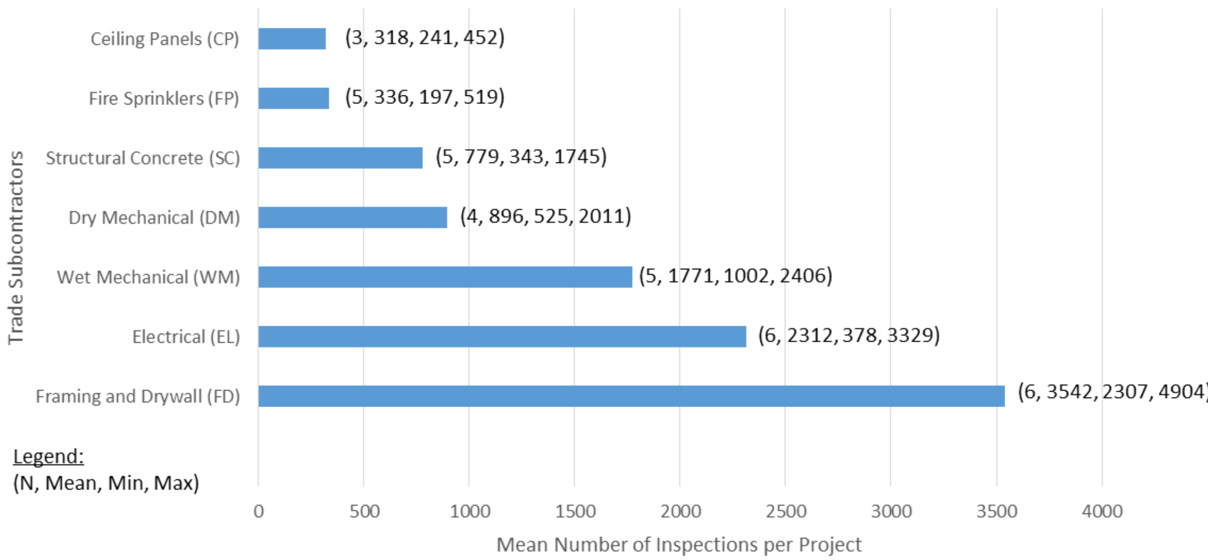

Figure 3: Subcontractors by trade and mean number of inspections per project.

Taking the analysis of that data one step further, the calculations above were then compared against the average total square footage and the average estimated initial total cost of those construction projects. The result of these calculations were reflected in figure 4 and 5 which show the likely number of inspections for each trade per total project square feet and per total dollars of estimated initial construction cost.

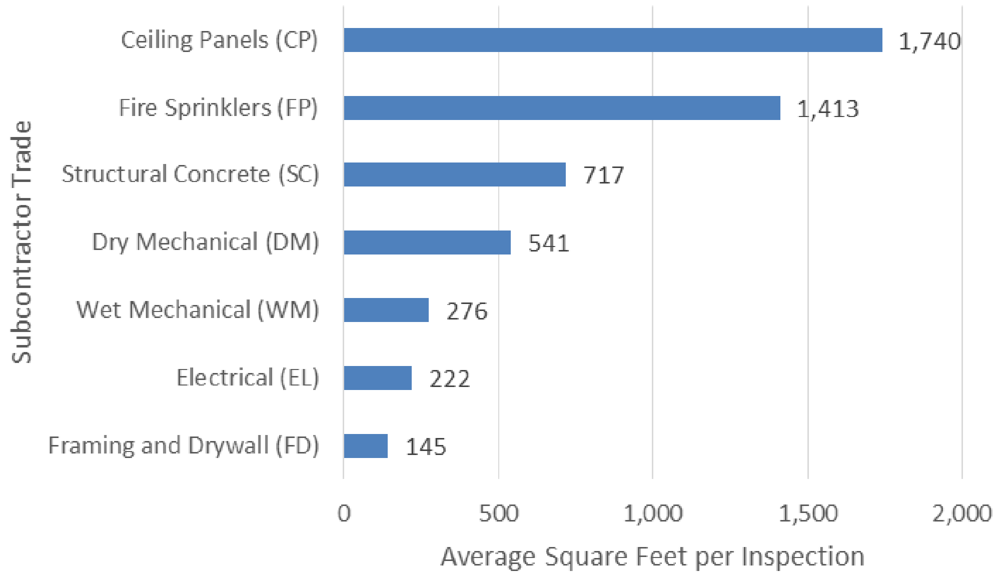

Figure 4: Subcontractors by trade and project square feet per inspection.

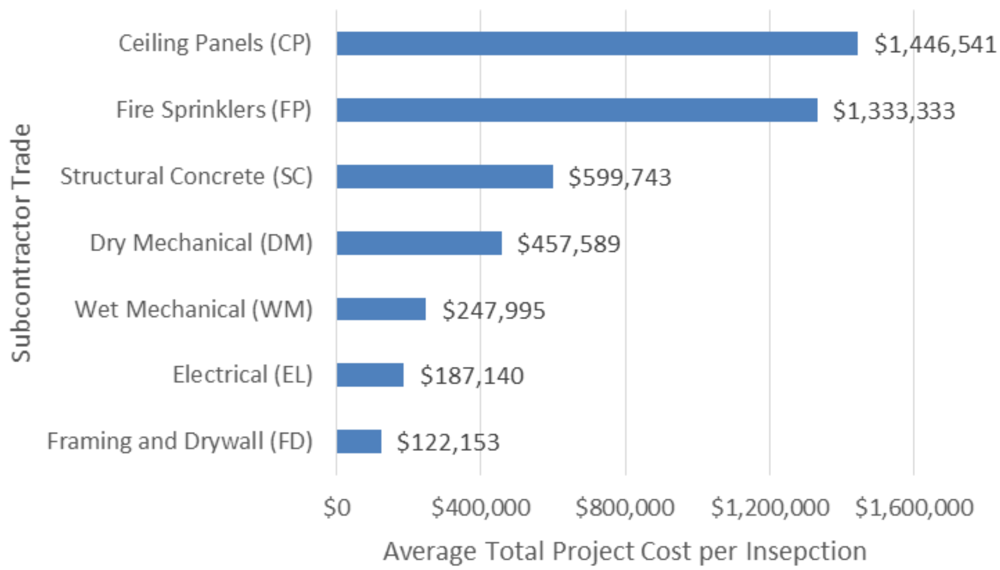

Figure 5: Subcontractors by trade and total project cost per inspection.

For example a framing and drywall subcontractor on a significant California hospital construction project might expect one inspection for every 145 SF of building project and one inspection for every $122,153 of total construction cost. A subcontractor in one of these seven ‘major trades’ could reasonably estimate how many inspections a particular project might require by knowing the total estimated construction cost of the project and/or the total square footage of the building. This could be valuable information when estimating and/or bidding a subcontractor’s total cost of a significant California hospital construction project.

Percentage of Failed Inspections

The percentage of OSHPD re-inspections (or failed inspections), which was mined from the same proprietary software data base, revealed that 9.07% of all inspections conducted did not pass inspection or failed (see figure 6).

	Minimum% (Best Perform)	Maximum% (Worst Perform)	Mean	Stnd. Dev.
Percentage of Failed (Total)	2.02%	21.82%	9.07%	5.559
Percentage of Failed (1st ¼)	0.00%	23.89%	6.38%	5.489
Percentage of Failed (2nd ¼)	0.46%	31.23%	7.98%	6.971
Percentage of Failed (3rd ¼)	1.04%	31.23%	9.76%	7.106
Percentage of Failed (4th ¼)	1.78%	38.86%	12.16%	9.646

Figure 6: Total failed inspections, null inspections, and quarterly failed inspections.

The result of a failed inspection is that work has to be redone (re-work), a new inspection must be requested, and a re-inspection is conducted by OSHPD. These additional steps are the true cost of quality (COQ) for a California hospital construction project. The overall re-inspection percentage number is based on over 60,000 inspection attempts with a standard deviation of 5.559.

From the proprietary software database, OSHPD inspections and re-inspections were date stamped. Meaning they had a time element which was documented and recorded for each inspection completed and failed inspection recorded. This allowed for the failed inspection analysis to occur over time. Since each subcontractor had a different quantity of work and time to complete that work, the dates recorded were broken down into quarters. The total number of inspections and failed inspections for each subcontractor were broken down into 25% (1/4 - quarter) increments and compared against the percentage of failed inspections which occurred over that same quarter.

The results of the inspections and failed inspections time-line analysis were consistent but counter intuitive, increasing each quarter from an average of 6.38% to 12.16% (see figure 6). As the project team worked together longer and better understood what the OSHPD inspectors were looking for, it could have been anticipated that inspection failures would decrease as the work progressed instead of increase. Further investigation is needed to better understand this unexpected occurrence.

Benchmarking Analysis

The percentage of failed inspections was also compared against all other subcontractors surveyed, ranking high achieving (low percentage of re-inspections) and low achieving (high percentage of re-inspections) as shown in figure 7. The electrical subcontractor was broken-out in this figure to be used as a specific example.

Subcontractor	Re-inspection Rate %	Subcontractor	Re-inspection Rate %
1. FD7	2.02%		
2. WM5	2.16%	22. WM1	7.98%
3. EL6	2.18%	23. EL2	8.33%
4. SC5	2.34%	24. DM3	9.06%
5. FD2	2.98%	25. DM1	9.58%
6. WM3	3.20%	26. FS2	9.86%
7. SC2	3.46%	27. FD4	9.88%
8. FD3	3.81%	28. IN2	10.07%
9. DM4	3.81%	29. FP2	10.96%
10. FD1	4.48%	30. FP3	11.95%
11. SC1	4.55%	31. IN1	12.11%
12. SC3	4.66%	32. FS1	12.38%
13. EL5	5.29%	33. CP2	13.05%
14. FD5	5.93%	34. GG1	13.82%
15. CP1	6.11%	35. CP3	14.94%
16. FP5	7.11%	36. EL4	15.28%
17. FP4	7.17%	37. WM4	17.71%
18. EL1	7.23%	38. FP1	19.33%
19. EF1	7.30%	39. WM2	20.28%
20. DM2	7.86%	40. SC4	21.76%
21. EL3	7.98%	41. FD6	21.82%

Electrical Subcontractor	Re-inspection Rate %
3. EL6	2.18%
13. EL5	5.29%
18. EL1	7.23%
21. EL3	7.98%
23. EL2	8.33%
36. EL4	15.28%
Average	7.72%

Figure 7: Ranking of subcontractors by percentage of re-inspections (or failed).

Based on an internal benchmarking analysis, each individual subcontractor might conclude that the percentage of OSHPD inspection failures they obtained on a particular hospital project were "normal" and should be expected for future projects. The second part of figure 7 focuses on the six data points in the EL – Electrical category. Without divulging any subcontractor's identity, EL1 and EL2 were the same electrical subcontractor. While this individual electrical subcontractor benchmarking analysis (from only two data points) might conclude that (7.23%) and an average (7.78%) re-inspection rates were conclusive benchmarks that could be used to measure and access future construction projects.

Continuing to use Barber (2004) conceptual progression nomenclature, competitor's benchmarking transitions the analysis from an internal to an external analysis. In this case competitor's benchmarking analysis represents all electrical subcontractors engaged in California hospital projects and the OSHPD inspection process. While this analysis only relies on six data points, electrical subcontractors best (2.18%) and average (7.72%) re-inspection rates could be used as better benchmarks for individual electrical subcontractors to measure future project inspection success against.

Industry benchmarking analysis includes all significant subcontractors working on California hospital construction projects. This analysis identified an overall best (2.02%) and average (9.07%) re-inspection rate which are likely the best benchmarks for subcontractors to measure future projects against. Further refining this benchmarking analysis based on a subcontractor work timeline and average inspection rate failures; 1st Quarter (6.38%), 2nd Quarter (7.98%), 3rd Quarter (9.76%) and 4th Quarter (12.16%) could also be beneficial for future comparison.

Conclusions and Future Research

Benchmarking results such as these would not only be useful to individual subcontractors on California hospital construction projects, but they would also be useful to general contractors, owners, and OSHPD inspectors. If the inspection failure rates were tracked from inception on a current project that data could then be compared against the 2%-7% of leading performer inspection failure rates and the 9.07% average failure rates. Non-conformance with benchmarks such as these could trigger project adjustments to bring inspection performance back within these norms. Field adjustments such as consistent drawing updates, communication routines, and quality assurance strategies (to name just a few) might be considered and implemented.

This type of inspection result data and industry benchmarking standards could also be used proactively as management incentive tools for field crews by the subcontractor main office, project general contractor and project owner. Essentially, either pitting subcontractor field crews against each other as a motivational tool in obtaining higher inspection success rates or consistently tracking and improving them over the duration of the project.

The potential for future research as a result of this work is significant. The old adage, which is generally attributed to Edward Deming "you can't manage what you don't measure" is the rudimentary goal of this study. Further individual trade inspection data points could be gathered to increase the certainty of these statistics. This data combined with a subcontractor survey could result in a predictive model to assist project teams, subcontractors, and field crews increase the probability of inspection success. This data combined with the true cost impact of failed inspections could be used to accurately estimate the cost of quality (COQ). The descriptive statistics contained in this study is a small step toward assisting California hospital construction project teams to decrease inspection failures and thus decrease the cost of quality associated with those failures.

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