BREADTH WORK – MECHANICAL/FIRE PROTECTION AND CONSTRUCTION MANAGEMENT

Mechanical/Fire Protection

With the layout of the braced frames, there was insignificant impact on the plans of the Hyatt. Spot checks of the plans were performed to determine if any mechanical changes needed to be evaluated based on the new layout. There were no significant changes to be made; however, in regards to fire protection, the new steel framing would need to be reviewed based on code specified fire ratings and new measures may need to be taken, such as the addition of spray on fireproofing. With the addition of heat, particularly in the case of a fire, the strength of the steel members is reduced, leading to possible failure.

Based on the classifications, the IBC 2003 selected occupancy group is R-1 for hotels with occupants that are not primarily permanent. The construction classification used in this case is type 1A. This classification requires a 3 hour fire rating for the structural frame, a 2 hour fire rating for the floor construction and a 1.5 hour fire rating for the roof construction. While the selected construction classification may not be the exact classification for the project, it is a conservative analysis and also provides a safer building for the occupants.

Grace Construction Products produces a spray applied cementitious fireproofing spray that is commonly used on steel beams, columns, and concrete/steel decking. Their product, Monokote® MK-6®, is mixed with water on the job site and applied as a cohesive slurry.

Product requirements were taken from the Underwriter's Laboratory Online Certifications Directory. From the Grace Construction Products website the steel beams can use UL Design No. N779 to provide a 3 hour fire rating, a 1" thick spray is required. For the columns, UL Design No. X772 is specified. For a 3 hour fire rating on an average sized column, a 2½" thick application is required. For the floor systems, primarily the composite decking, a 2 hour fire rating can be achieved with UL Design No. D780, with an application of 5/8" thickness.

The addition of the fireproofing has an impact in increasing the overall cost of the steel framing. A rough approximation of the increase in cost is based on the total linear feet of columns and beams and a square footage of decking. From calculation in R. S. Means, the approximate increase in cost is $500,000.

Construction Management

When comparing alternative framing systems, other considerations are the impacts on the construction management of the project. In many cases the cost or time schedule of a project dominates the design rather than what might be the best choice in the opinion of the structural engineers or architects.

Cost Estimate

For the Hyatt project, a cost estimate has been calculated for the existing structure as well as the new structural design. Using the R. S. Means Building Construction Cost Data 2006, the cost of the framing members has been calculated. In the case of the concrete framing, the estimate was calculated based on the number of cubic yards of cast-in-place concrete for the columns and slab and based on a total square foot calculation of the filigree precast plank. Final results are shown in Table 2. Additional calculations can be found in Appendix F.

Table 2. - Concrete Cost Estimate
Total Building Cost

Precast Plank	$952,680
C.I.P. Slab on Plank	$52,662
C.I.P. Columns	$1,117,282
Total Cost =	**$2,100,000**

The cost per cubic yard for the columns includes a crew of 25, including a foreman, carpenters, rodmen (reinforcement placement), laborers, a cement finisher, and an equipment operator for the concrete pump. It also includes the cost of a gas engine vibrator and the use of a concrete pump. In addition to the crew, the cost for the columns also includes forms, concrete, placement of the concrete, reinforcing steel, and finishing costs. The cost per cubic yard of the slab includes a crew of 9, including a foreman, laborers, cement finishers, and equipment operators. It also includes the cost of 2 gas engine vibrators, a concrete bucket, and a crane for placement. The cost for the filigree precast plank was taken as the cost for a lightweight concrete precast plank from the Cementitious Decks & Underlayments section of R. S. Means. While this may not exactly represent the actual cost of the filigree slabs, it does provide an estimate to the cost of similar construction. The cost includes a crew of 6, including a foreman, carpenters, a laborer, and an equipment operator. Also included is the use of a crane for plank placement.

For the cost of the new design, the cost was calculated primarily on the basis of total linear feet of each W-section used. To determine the linear feet of steel used, takeoffs from RAM were used to summarize the sections used and compute the actual lengths to be used for the cost estimate. For the slab and decking, total square footage was used; for the shear studs, the value was based on the total number of studs. Final results are shown in Table 3. Additional calculations can be found in Appendix F.

Table 3. - Steel Cost Estimate
Total Building Cost

Gravity Beams	$1,185,164
Gravity Columns	$410,046
Frame Beams and Braces	$249,257
Frame Columns	$256,027
Shear Studs	$33,010
Decking and Slab	$734,400
Total Cost =	**$2,900,000**

The cost per linear foot for the various members was in some cases estimated from the values in R. S. Means. As some W-sections are not included for estimates, similar shapes and sizes were used to calculate some member costs. The cost for the structural steel includes a crew of between 6 and 10, depending on the sizes of the members, including foremen, steel workers, welders, and equipment operators. The costs also include the use of a crane and welding machine. For the decking, the cost includes a crew of 4, including a foreman and steel workers; it also includes the use of a welding machine. For the shear studs, the cost includes a crew of a foreman and a welder as well as the use of a welding machine. The slab is calculated similar to the slab for the concrete design including a similar crew.

Based on the cost estimates calculated, the steel framing would cost $800,000 more than the existing concrete framing. Note that this does not include the approximated cost of $500,000 in the fire protection breath study. It can also be noted, however, that the cost does not factor in any savings that may be involved with reduced number of piles at each pile cap. In the scope of the whole project, this only represents around a 5% increase in cost. For the purpose of this comparison, the increase in cost is unfavorable.

Time Estimate

In addition to a cost comparison, the approximate time for construction has been calculated based on the same units that the cost estimate was based on. The daily output value represents the number of units (cubic yards, square feet, linear feet, etc.) that can be constructed in a day. By dividing the units required by the output per day of the given crew, the resulting time for construction is estimated.

In the case of this comparison, the existing concrete framing was given a time estimate of 220 labor days. The new steel framing was calculated to take only 205 labor days. This time savings of 15 labor days would result in 3 weeks (5 labor days per week) time savings with the steel framing. It should be noted however, that with increased number of crews, it may be possible for the cost of the concrete framing may be able to reduce this difference with minimal additional cost. The daily outputs were simply calculated based on the given crew size that is assumed in R. S. Means. Calculations can be found in Appendix G.

Conclusions from Breadth Work

Overall, the breadth work seemed to show more disadvantages of the steel framing. With the upgraded fire protection, the cost of the project would increase significantly. In addition, the construction management cost analysis showed that the time savings were not very significant for the increase in cost.

The spray fireproofing ratings showed that steel can easily meet the code requirements for structural members. Only a 1" thick spray on beams, 2 ½" thick spray on columns, and a 5/8" thick spray on the decking provided the fire rating required.

Although it was not fully developed due to poor soil reports, the number of piles required may have decreased and in turn decreased the difference in cost from concrete to steel framing. The use of filigree precast slabs in the original design greatly increases the speed of that type of concrete construction. With cast-in-place slabs, the steel framing would typically have provided a much faster construction time.