STRUCTURAL TECHNICAL REPORT 3 **12 November 2002**

EXECUTIVE SUMMARY

The following report summarizes the vital information pertaining to the lateral structural system of the Discovery Communications Headquarters in Silver Springs, MD. This building is comprised of 2 structurally independent office towers built above 3 levels of underground parking. This building does not contain any shear walls, thus the gravity systems also act as the lateral resisting system. Given this buildings use, location and site classification, it is classified as category B for seismic design. Thus, equivalent lateral force procedures are to be used for seismic design of the building. Wind and seismic loads were calculated from BOCA 96 code for the lateral analysis.

Through inspection and later confirmed by computer analysis it was determined that the floor slab acts as a rigid diaphragm and will distribute lateral load evenly to the frames in the same direction as the imposed load. For the North Tower, 5 frames will take the lateral load in the east-west direction, 13 in the north-south direction. For the South Tower, 5 frames will take the load in the north-south direction, 8 in the east-west direction. These frames when subjected to service wind and seismic loading, along with additional gravity loads, performed within the acceptable deflection criteria of H/400. Also when subjected to factored loads, they were able to meet the necessary strength requirements.

Because the lateral systems of these building are almost symmetrical very little torsion was experienced through normal means. For this reason a false eccentricity of 5% the building width was used to create an incidental torque on the building during lateral loading. With the use of lateral moment frames in both directions, it is feasible to allow the frames perpendicular to the direction of the lateral load to account for this torsional moment. Also because the forces associated with this torsional moment being mush smaller then those produced by lateral loading, these frames are more then adequate to handle the torsion load. Lastly, during lateral loading the building will experience an overturning moment due to this loading, which will act to topple the building. However, in the case of these buildings the overturning moment was found to be much less then the moment cause by the buildings deadweight. Thus overturning is not a concern for either of these buildings.

LATERAL SYSTEM

This building is comprises of 2 structurally independent office towers of 10 and 7-story heights and are separated south of the center atrium by a 2 inch isolation joint. Three levels of underground parking are located beneath both towers and the west courtyard. Designed using cast-in-place reinforced concrete as the main structural material, it incorporates a flat-plate, 2-way slab system with columns generally placed 30 feet on center. This 9" thick slab is generally reinforced with a bottom mat of #5 reinforcing bars along with a top mat ranging in reinforcement size from #4 to #7.

Columns with 7.5 " drop panels, generally spaced on 30 foot centers, support the floor slabs. These columns are 30"x30" throughout the office levels and increase in size below grade. Reinforcement for these columns varies with location and loading. Also, compressive strength of the columns increases from 4,000 psi to 10,000 psi as they move down the building. There are no shear walls used in this structure, leaving the gravity load elements, slabs and columns, to provide the necessary lateral resistance. Thus, the structural elements would be classified as a moment resisting building frame system.

LOAD COMBINATIONS

Basic gravity and lateral loads were calculated for this building to form a basis for the structural analysis. The codes used for the original design were also used in this report to compute all loadings. BOCA 96 and ASCE 7-97 were used to calculate the wind and seismic lateral loads, respectively. Also, BOCA 96 was used to calculate lateral soil pressures on the parking levels and snow loads, including drift, on the building roofs. Calculations and necessary code references for computing loads can be found in Appendix B. The following represents a summary of these loads.

WIND LOADS

Wind loads were calculated using BOCA 96 building code. The loading diagrams below represent the imposed windward and leeward pressures on each tower in both major directions. Geometry factors have not been introduced at this time. Calculations, roof pressures and sidewall pressures can be found in Appendix B.

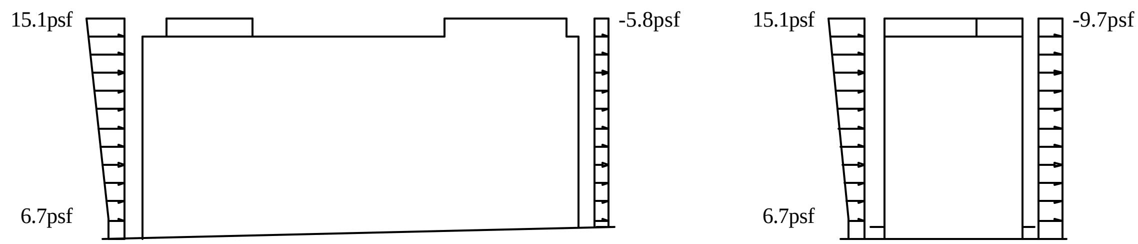

Figure 1 - North Tower Wind Pressures

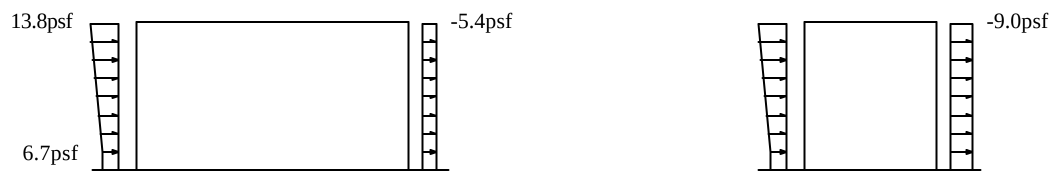

Figure 2 - South Tower Wind Pressures

SEISMIC LOADING

After initial inspection of the structure including its seismic location, site classification and lateral resisting system, the buildings seismic design category was determined as category B. This category allows equivalent lateral force procedures to be used for seismic design of the building. The loading diagrams below represent the lateral story forces on the building due to seismic loading. Calculations can be found in Appendix B.

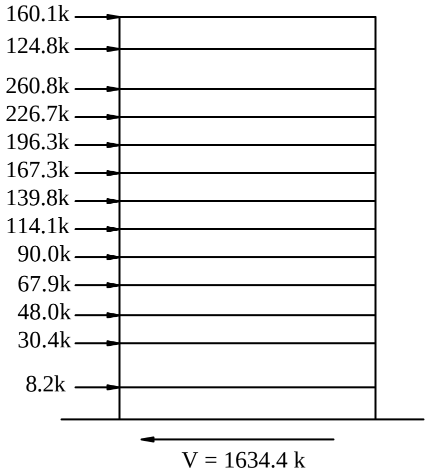

Figure 3 - North Tower Seismic

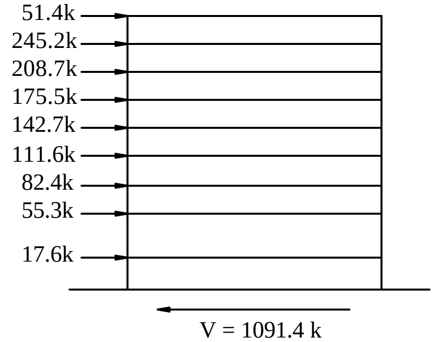

Figure 3 - South Tower Seismic

Given the size and overall mass of these buildings, there are two major lateral forces that this building is subjected to, wind and seismic loading. When the normal gravity loads are also considered, the following load combinations must be considered during the lateral analysis of these buildings:

1.2D + 1.6W + 1.0L + 0.5S (1)

1.2D + 1.0E + 1.0L +0.2S (2)

These combinations, taken from chapter 9 in the AISC 318-02, account for the most likely combinations of gravity and lateral load to be imposed on the building. Because the lateral system of this building is also the gravity system, both gravity and lateral loads most be imposed on the structure while checking strength and deflection criterion.

The overall shapes of the buildings add an additional element to the analysis of the lateral system. While the seismic loads are dependant only on the weight of the building and are the same in both directions, this is not the case for wind loads. Because these buildings are significantly longer in one direction, the wind load, being dependant on surface area, is much smaller when acting on the short side of the building and much larger when acting on the long surface. This difference is large enough for the imposed wind load to surpass the seismic load when acting on the long face and is less when acting on the short surface. Thus, load combination 1 will control when analyzing the lateral system in the short direction and combination 2 will govern in the long direction. These controlling cases were later confirmed through computer analysis.

LOAD DISTRIBUTION

These buildings are constructed using cast-in-place concrete as the structural system. Because of this, the floor slabs are able to act as rigid diaphragms at every floor level. These slabs do no deflect under lateral loading and effectively tie all the columns and frames together at each floor level. Thus the lateral frames must all deflect the same distance during loading. Also, these lateral frames are identical along a given axis of the building and therefore have the same stiffness. Because of these to factors any lateral load applied to the face of the building will be transferred from the façade to the floor slab which will equally distributed the load among the lateral frames in the same direction.

With the above factors taken into consideration the following conditions will be used for testing the lateral systems of each building. In the long direction of the north tower the lateral load will be distributed to the 5 frames in that direction. In the short direction, the load will be evenly distributed to the 13 frames providing resistance in that direction. In long direction of the south tower, the lateral load will be distributed to 5 lateral frames. Lastly, in the short direction of the south tower, the load will be evenly distributed to 8 frames. These distributions apply to both seismic and wind loading.

ANALYSIS OF THE LATERAL SYSTEM

Because these buildings are constructed using cast-in-place concrete the structure is structurally indeterminate. For this reason models were created in STADD of the required lateral resisting frames. These frames include the typical frames in both the north and south tower in both the north-south and east-west direction for a total of four frames. Only one frame for each direction of each building was required because they are identical in each circumstance except for some very minor exceptions, which can be neglected.

For these frames each floor, including the underground parking levels, were modeled. These frames were created using the total allowable width of slab 360", which is the center of span to center of span distance. Also, drop panels were appropriately modeled. Because the footings for this building are not extremely large, 6'x6', their have very little ability to transfer moment, therefore column fixity was assumed as pinned. Lastly, because there is a retaining wall located around the perimeter of the parking levels it was assumed that no movement would be permitted below ground level. Thus a pin located at the first floor slab was used to negate lateral movement at this elevation and below.

Once the computer models were completed forces were appropriately distributed to the frames for, dead, live, snow, wind and seismic loading. When applied to the frames and analyzed, the following deflections were found below. As can be seen from the chart, the buildings easily surpassed the accepted wind deflections of H/400. Computer Model diagrams and results can be found in Appendix D.

Maximum Building Deflection				
Location	1.2D+1.6W+1.0L+0.5S	1.2D+1.0E+1.0L+0.2S	Service Wind	Wind Criterion
North Tower - NS	5.58"	3.36"	3.90"	H/500
North Tower - EW	1.20"	1.68"	0.93"	H/2100
South Tower - NS	1.40"	1.89"	1.09"	H/1200
South Tower - EW	2.94"	2.31"	2.08"	H/600

Torsion caused by lateral loading is another problem that must be handled with by the lateral system of the building. Torsion occurs when the imposed lateral load does not act on the center of rigidity of the building. This, in turn, creates a moment within the lateral systems of the building that must be accounted for. Because these buildings uses identical frames evenly spaced throughout the length of the building, the center of rigidity coincides with both the center of mass and the actual center of the building. Thus, there is no naturally occurring eccentricity in these building and therefore no torsion.

While torsion may not occur in the building due to its layout, it may occur for some unforeseen reason and thus a false eccentricity of 5% the building length must be introduced, causing a torsional moment within the building. This moment must then be accounted for in the lateral systems of the building. Because these buildings use lateral moment frames on both directions it feasible to allow the frames perpendicular to the direction of the lateral load to account for this torsional moment. Also, because the force required to resist this moment is relatively small when compared to the direct lateral force imposed on these frames, it can be assumed that the frames can adequately carry this load. Calculations pertaining to the torsion loading on these buildings are located in Appendix B.

Lastly, when buildings are exposed to lateral loading they must resist the tendency of these forces to push the building over. This is known as the overturning moment. This moment caused by the lateral loads experience along the height of the building are resisted by the moment created by the buildings own self-weight. This overturning moment must not exceed two-thirds that of the self-weight moment. A chart containing this information is found below. Also, calculations are located in Appendix B.

Overturning Moments			
Location	Overturning (ft-k)	Self-Weight (ft-k)	% of Self-Weight
North Tower - NS	102779.31	3616062.35	2.84%
North Tower - EW	69835.32	10720184.25	0.65%
South Tower - NS	37438.58	3523861.50	1.06%
South Tower - EW	42747.47	1714311.00	2.49%

STRENGTH CHECK

Two members were analyzed for strength issues with in the lateral systems of the building. These members, a beam and a column, are located on the 8^{th} floor of the north-south frame on the north tower. Also, because they are located on the opposite end from where the lateral forces are applied, these members experience the worst bending case for the entire floor. These members were chosen because they reside in the frame that had the most severe defection and thus the most stress. Lastly, because all the frames in both buildings are constructed using the same slab, drop panels and columns, this would provide the worst case for all the lateral frames. When these members were check for strength under both load case mentioned before, they were found to be more then adequate to carry the imposed loads. Calculations for these members can be found in Appendix C.

CONCLUSION

The current lateral system, consisting of cast-in-place concrete moment resisting frames was found to be more then adequate for the loads experienced by the building. Under service conditions the building deflections were well within the accepted value of H/400. This is most likely due to the unusually large columns used throughout the building. These 30”x30” columns provide a very high amount of stiffness to the lateral system of the building making a large impact on deflection. However, if smaller columns were used slenderness issues could play a role in the design of the building. Lastly, when subjected to factored loads, they were able to meet the necessary strength requirements.

With the lateral systems spaced symmetrically around the buildings, no torsion is experienced under normal lateral loading. Because torsion dues not occur naturally, a false eccentricity of 5% the building length was introduced, causing a torsional moment within the building. Because these buildings use lateral moment frames in both directions it the frames perpendicular to the direction of the lateral load are able to account for this torsional moment. Also, because the force required to resist this moment is relatively small when compared to the direct lateral force imposed on these frames, it can be assumed that the frames can adequately carry this load. Lastly during lateral loading the building will experience an overturning moment due to this loading, which will act to topple the building. However, in the case of these buildings the overturning moment was found to be much less then the moment cause by the buildings deadweight. Thus overturning is not a concern for either of these buildings.