THE ANALYSIS OF HORIZONTALLY OFFSET DIAPHRAGMS

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ABSTRACT

The structural configurations of many modern buildings require very complex lateral load paths that incorporate diaphragms at different elevations, multiple re-entrant corners, multiple irregularities, and fewer vertical lateral-force-resisting elements. This paper discusses a method of analyzing diaphragms with horizontal offsets and how to transfer member forces across areas of discontinuity.

KEYWORDS: Diaphragm, discontinuity, offset, transfer diaphragm

1 DISCUSSION

Code requires that a complete continuous lateral load path, or paths, with adequate strength and stiffness must be provided to transfer all forces from the point of origin to the final point of resistance. All edges of diaphragms must have boundary members consisting of drag struts, chords, collectors or other vertical lateral-force-resisting elements. The load path must include all of the connections necessary to make members in the line of lateral-force resistance act as a unit and transfer the shears and forces from the diaphragm sheathing into the boundary elements, across any discontinuity, then into the vertical force-resisting elements, and finally down into the foundation.

Discontinuities in diaphragms are often created when a portion of an exterior wall line is offset from the main wall line, which causes a disruption in the diaphragm chord or strut. By code, whenever this occurs, the disrupted chord or strut force must be transferred across the discontinuity through an alternate load path. It is important to remember that at diaphragm discontinuities, such as offsets, openings or re-entrant corners, the design must assure that the dissipation or transfer of edge (chord) forces combined with other forces in the diaphragm is within the shear and tension capacity of the diaphragm. All irregularities and/or discontinuities within a diaphragm or system of diaphragms and shear walls must be addressed.

2 METHOD OF ANALYSIS

In order to successfully solve the problem of transferring forces through areas of discontinuity, it is important to understand how shears are distributed into and out of a diaphragm. The discontinuous chord at grid line 2C, as shown in Figure 1, is typically extended into the main body of the diaphragm by the use of a continuous light gauge steel strap and flat blocking, with the intent of overlapping and transferring the disrupted chord force into the main diaphragm chord at grid line C.

In order to effectively distribute the force into the diaphragm, in accordance with code, a portion of the diaphragm to the right of the discontinuity must act as a transfer diaphragm (TD), which receives the disrupted chord force and distributes it out to the main diaphragm chords at grid lines A and C. The transfer diaphragm acts like a beam with a concentrated load applied as depicted by the inset diagram. This method of analyzing diaphragms

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with offsets and openings was developed by Edward F. Diekmann, of GFDS Engineers in San Francisco [2][3].

The main diaphragm and transfer diaphragm are already under shear from the uniform load, as calculated in the basic shear diagram. Additional transfer diaphragm shears are created by the disrupted chord force. The transfer diaphragm shears must be added to or subtracted from the basic diaphragm shears, to accurately account for the combined localized effects within the transfer diaphragm, resulting in net shears occurring within the transfer diaphragm area. This complies with the code requirement of “combined with other forces”.

3 CONCLUSION

This method of analysis can be used to solve most of the complex diaphragm layouts experienced today. Modern complex structures require careful attention to how the loads are distributed through the structure, how these forces are transferred across discontinuities, and to the details necessary to allow the transfer of those forces. When highly irregular diaphragms are viewed as a whole, a rational design of the lateral force resisting paths may seem daunting; however, when approached one section at a time, keeping in mind our statics, a robust design can be developed. Most of the problems and challenges presented by these structures can be resolved by using simple statics.

REFERENCES


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