The Hambro Slab as a Diaphragm

With the increasing use of the Hambro system in earthquake prone areas such as Anchorage, Los Angeles, etc., as well as in high buildings, a testing program was conducted to clearly establish how the Hambro Composite Floor System behaved as a diaphragm in transferring horizontal shears to the supporting structure.

Objective

To study the behavior and strength of the Hambro System acting as a diaphragm, and to determine a suitable structural design method.

Description

Fourteen small-scale test specimens, *2 feet* x *3 feet* were tested in the Structures Laboratory of Carleton University, using the *120 kip / 54.5 M* tonne capacity Tinius Olsen Universal testing machine. The specimens were set up in such a way as to induce extremely high shear forces in the slab, thereby leading to shear failures. The specimens incorporated the following variable conditions:

- Variable slab thicknesses
- Variable concrete strengths
- Variable direction of embedded top chord parallel and perpendicular to direction of applied load
- Variable mesh size

Control specimens which did not have any top chord were used as the basis for comparison.

Close observations were made of each test specimen to determine general behavior, such as cracking and actual failure modes.

Results and Discussion

The test specimens yielded meaningful results – test data correlated very well with the “shear friction” design approach, which is outlined by the ACI (American Concrete Institute) Standard 318. The tests clearly established that the horizontal shear resistance of the slab is dependent **only** on the “available” mesh steel area that passes over the top chord.

The following is a synopsis of the significant test results:

1. Shear friction, i.e. cracking along the top chord, is the dominant mode of failure and always occurs before flexural or diagonal tension failure.
2. Diaphragm buckling, i.e. vertical movement of the slab due to lateral loads, will not occur provided that the joists are prevented from vertical movement at their supports and thus are forced to bend and provide resistance to any out of plane movement of the slab.
3. For shear force transfer perpendicular to the direction of the ʅ, the test specimen behaved as if the ʅ were not present.
4. The weakest condition is shear force transfer parallel to the direction of the ʅ .
5. The calculated shear friction failure load (via ACI 318) is conservative and always less than the actual test specimen failure loads.
6. Drift or lateral movement of the slab can be calculated as the sum of the flexural and shear deflections.
7. Using the shear friction approach, the procedure to design Hambro slab as a diaphragm is the same as a conventional slab.