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Torsional performance of coupled channels in tall buildings

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The Authors present very useful results based on experimental elastic and elasto-plastic torsional tests on models of coupled channels. The results are based on terminal torsion and single level torsion. Uniformly distributed torsion has not been considered. A combination of these loadings should simulate earthquake effect.

27. It is observed that the rotation of model 3 is less than that of model 2 for the same terminal twisting moment. Model 3 therefore has higher torsional rigidity than model 2.

28. Higher values of EI_w/GK, where GK is pure torsional rigidity and EI_w is sectorial or warping rigidity, indicate that warping action is predominant.[22] This ratio is higher for model 2 than it is for model 3, so the warping action should be more predominant in model 2 than it is in model 3. The crack pattern for model 2 indicates that large bimoments were produced at the base of the shaft, thereby establishing warping stresses in the shaft.

29. In coupled channel cores the floor slabs act as diaphragms which, because of their in-plane stiffness, give rigidity to the cross-section. The Authors use a system of angles as diaphragms. They do not mention angle size. However, the angle appears to be wider than the usual floor thickness, which would give rigidity to a longer element of the cross-section than is in fact so.

30. Distortion is a torsional effect. Floor slabs, which act as diaphragms, prevent the distortion of coupled channel cores. Any distortion, if present, is indicated by unequal bending of coupling beams. Did the Authors observe any distortion in the model cores they tested?

31. Kilam[23] observed longitudinal warping stresses along the vertical edges of the cut-outs. He found that experimental values of these stresses were higher than the theoretical values.

32. A hollow rectangular section which does not have the corners rounded both internally and externally has a stress concentration at the inner corners when subject to torsion.[24] The stress concentration can be reduced considerably if material is removed from the outside corner in a manner which leaves material of nearly uniform thickness at the junction of the walls. Therefore the core cross-section shown in Fig. 10 is suggested.

33. The Structural Engineers' Association of California earthquake code[25] requires the vertical resisting structure to be capable of resisting a minimum torsional load equal to the lateral load multiplied by 5% of the maximum building dimension.

34. Can the Authors explain how their results could be applied to the interaction of coupled channels and frames under torsional loading?

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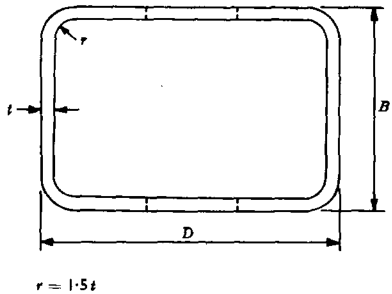

Fig. 10. Cross-section with rounded corners for core

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Mr Khanna states that a combination of uniformly distributed torque and a single level torque should simulate an earthquake loading. Caution should always be exercised in choosing equivalent earthquake loadings, especially those acting on individual units which are only part of a complex structure because often there is a continual redistribution of lateral loading throughout the height of tall buildings among the various vertical load bearing units.

36. Model 3 has thicker wall sections and larger overall cross-sectional dimensions than model 2 and so it is to be expected that model 3 should be able to withstand a greater twisting moment than model 2.

37. Warping is, of course, present in the twisted sections and the warping of the cross-sections of the top of each model was measured. The greater warping occurred in model 2 which may be partly explained by the fact that model 3 has a more thick walled section.

38. Equal angles of 30 mm were loosely fastened to the models to apply the twisting moments. During the tests local stiffening of the models from the angles was not apparent but in later model tests[26] rubber inserts were used to remove the possibility of warping restraint and local stiffening of models from the loading mechanism. Distortion of the models cores from the angles did not occur. This was watched for very closely during the tests in which all the connecting beams showed flexural cracks in the plane of the walls they connected and not out of plane, which could have been caused by distortion of the cores. At complete failure of the models they were spiralled to some degree.

39. Kilam[23] found that experimental warping stresses were greater than calculated values, but this merely indicates that some modification needs to be made to the theory such as may be required to incorporate the effect of flexibility of beam to wall connections or elasticity of foundations.

40. The greatest resistance to torsion from a given cross-sectional area of material is achieved by forming the material into a circular tube which eliminates re-entrant corners and stress concentrations. Where this is not practical the introduction of a fillet as suggested by Hopkins[24] is probably an improvement over the rigid rectangle, but again this can lead to construction difficulties and problems in housing maximum services in the core.

41. It is widely accepted that a torsional load of 5% of the maximum plan dimension of a building times the lateral load is often much less than the torsional loading which is likely to act on a building during an earthquake. In many instances a dynamic analysis of the complete building should be carried out to determine the maximum probable translational and rotational load patterns likely to act on the building during an earthquake and the distribution of these loadings among the various vertical load bearing

units throughout the height of the structure. This can be carried out using, say, reference 27 with the appropriate unit properties for frames, walls and cores inserted. The results presented in the Paper can then be used as a guide to assess the likely performance of the individual units.

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