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Deflection problem in RC members

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Deflection check is generally relevant for bending members like slabs and beams. Limit state of deflection is a serviceability requirement, and not a safety requirement. When the deflection of a member is more, it does not mean that it is structurally unsafe, it only means that visually it may look ugly and brittle finishes and partitions, if resting directly on it, may crack, but there will be no cracking in the deflected structural member which is, otherwise, adequately designed for moment and shear. So, deflection problem is viewed not as a serious problem from the safety point of view.

For checking the adequacy of bending members in respect of deflection, the code, IS 456:2000 gives two approaches, one is computation of deflection and the other is $\frac{l}{d}$ ratio method[1]. The method of computation of deflection is a strict method, but is laborious and time consuming. The $\frac{l}{d}$ ratio method is an approximate and quick method and it is easy to follow in design practice[2]. The calculated total deflection of a member should not exceed $\frac{l}{250}$. This condition is easy to satisfy in practice by providing adequate camber to the formwork before the member is cast. So, this condition is not governing in design. The other condition is that the calculated partial deflection of a member due to loads of finishes, partitions, live loads, temperature, shrinkage and creep should not exceed $\frac{l}{350}$ or 2 cm whichever is less. This condition is difficult to satisfy in practice and it governs the design. This condition can be satisfied by assuming a suitable camber and also by assuming half the effect of temperature, shrinkage and creep, as these loads are slow acting in nature. For members longer than 7 m in span, 2 cm requirement is also difficult to satisfy. It is suggested that 2 cm requirement should be deleted and only $\frac{l}{350}$ requirement should be insisted upon, this being in line with the ACI code[3]. These two approaches of the code will tally in a given example, if a suitable camber is assumed and the long-term deflection due to temperature, shrinkage and creep is halved. This is shown in a worked example given elsewhere[4].

In practical design of beams $\frac{l}{d}$ ratio method is used as the beam depths in practice are chosen on the higher side for reducing steel consumption in beams. But, when a particular beam has to be restricted in depth for architectural reasons, the computation of deflection method has to be adopted to justify the reduced depth of the beam. Also the code specifies that for cantilever beams of spans longer than 10 m, deflection needs to be calculated and $\frac{l}{d}$ ratio method will not be then acceptable. Variation of about 5-10 percent in the calculated and the acceptable values of deflection or $\frac{l}{d}$ ratios is allowed, as the deflection is a serviceability requirement[5].

The deflection requirements of the code have complicated the practical design of slabs in two respects. Firstly, the slab design involves iteration and secondly, the slab panels work out thicker than before when the design was based on the old code[6]. The iteration in slab design can be easily avoided by using charts given elsewhere[7]. But the problem of thick slab panel adds to the cost of buildings and the method suggested in SP:24 should be used, where more steel is provided at the mid span in order to get slab panels of less thickness[8].

When a slab panel is not supporting brick partitions, slab thickness can be further reduced using the minimum values given in the old code[6]. The code is silent on this aspect and the young structural engineers fail to appreciate this point. We have learnt these ideas from our seniors in the profession and Fintel has also written in support of thin slab panels for an overall economy in building design[9]. A useful table given elsewhere will be highly beneficial to choose thickness of slab panels, which will be conducive to economy and also avoid iteration in slab design[10]. It needs to be highlighted that adequate care should be taken in selecting slab thickness, especially when the slab is subjected to dynamic loads and vibrations.

On the analogy of thin slab panels, we cannot go in for beams of less depth for two reasons. One reason is that concrete quantity in beams is of the order of 15 percent of the total concrete quantity of the entire building, while the same in slabs is of

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the order of 65 percent. The second reason is that steel consumption in beams is high and it will go up sharply if beam depth is reduced. In slabs, steel consumption is less and it will, no doubt, go up when the slab thickness is reduced, but the total steel consumption in the building will not be much increased. So, for an overall economy in building design, beam depth should be chosen on the higher side and slab thickness on the lower side, at any rate, not lower than those given in the old code[6].

$\frac{l}{d}$ ratio method given in clause 23.2 of the code rightly applies to beams only. But in clause 24.1 of the code, it has been extended to slabs also. This extension is correct for one-way slabs only, but its application to two-way slabs and flat slabs/ plates is wrong in principle, in that, these slab panels bend in two principal directions, while beams span in one direction only. The deflections in two-way slabs work out quite small and $\frac{l}{d}$ ratio method leads to large slab thicknesses erroneously. The computation of deflection method can be correctly applied to two-way slabs and flat plates and examples have been worked out elsewhere[11,12].

An attempt has been made here to highlight major issues involved in the deflection problem of bending members in order to achieve economical and efficient design of these members for the limit state of deflection.

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