## 3.3 Analysis for gravity loads

### Simple framing

If a simple framing is used, the analysis is quite simple because they can be considered as simply supported. In such cases, shears and moments can be determined by statics. The gravity loads applied to the columns are relatively easy to estimate, but the column moments may be a little more difficult to find out. The column moments occur due to uneven distribution and unequal magnitude of live load. If the beam reactions are equal on each side of interior column, then there will be no column moment. If the reactions are unequal, the moment produced in the column will be equal to the difference between reactions multiplied by eccentricity of the beam reaction with respect to column centre line.

### Semi rigid framing

The analysis of semi-rigid building frames is complex. The semi-rigid frames are analysed and designed by using special techniques developed based on experimental evidence on the behaviour of the connections. For more details the reference quoted in the chapter on beam-to-column connections may be consulted.

### Rigid framing

Rigid frame buildings are analysed by one of the approximate methods to make an estimate of member sizes before going to exact methods such as slope-deflection or moment-distribution method. If the ends of each girder are assumed to be completely fixed, the bending moments due to uniform loads are as shown in full lines of Fig. 3.8(a). If the ends of beam are connected by simple connection, then the moment diagram for uniformly distributed load is shown in

Fig. 3.8(b). In reality, a moment somewhere between the two extremes will occur which is represented by dotted line in Fig.3.8(a). A reasonable procedure is to assume fixed end moment in the range of $wl^2/10$, where l is clear span and w is magnitude of uniformly distributed load.

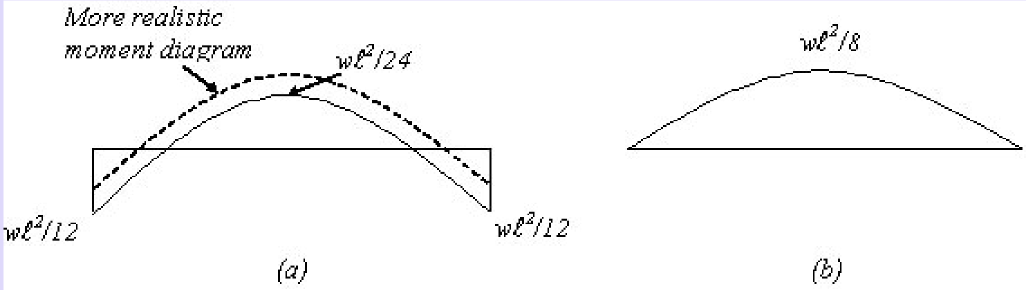


**Fig. 3.8 (a) Fixed beam**

**(b) Simply - supported beam bending moment diagrams**

The following assumptions are made for arrangement of live load in the analysis of frames:

a) Consideration is limited to combination of:

1. Design dead load on all spans with full design live load on two adjacent spans and

2. Design dead load on all spans with full design live load on alternate spans.

b) When design live load does not exceed three-fourths of the design dead load, the load arrangement of design dead load and design live load on all the spans can be used.

Unless more exact estimates are made, for beams of uniform cross-section which support substantially uniformly distributed loads over three or more spans which do not differ by more than 15% of the longest, the bending moments and shear forces used for design is obtained using the coefficients given in Table 3.2 and Table 3.3 respectively. For moments at supports where two unequal spans meet or in cases where the spans are not equally loaded, the average of the two values for the hogging moment at the support may be used for design. Where coefficients given in Table 3.2 are used for calculation of bending moments, redistribution of moments is not permitted.

## Substitute frame method

Rigid frame high-rise buildings are highly redundant structures. The analysis of such frames by conventional methods such as moment distribution method or Kane's method is very lengthy and time consuming. Thus, approximate methods (such as two cycled moment distribution method) are adopted for the analysis of rigid frames under gravity loading, one of such methods is Substitute Frame Method.

Substitute frame method is a short version of moment distribution method. Only two cycles are carried out in the analysis and also only a part of frame is considered for analysing the moments and shears in the beams and columns. The assumptions for this method are given below:

1) Moments transferred from one floor to another floor are small. Hence, the moments for each floor are separately calculated.
2) Each floor will be taken as connected to columns above and below with their far ends fixed.

If the columns are very stiff, no rotation will occur at both ends of a beam and the point of contraflexure will be at about 0.2 l. The actual beam can be replaced by a simply – supported beam of span 0.6 l as shown in Fig. 3.9(a). If, the columns are flexible, then all the beams can be considered as simply supported of span l as the beam – column joint will rotate like a hinge, an approximate model for middle floor beam is shown in Fig. 3.9(b).

**Table 3.2: Bending moment coefficients**

| TYPE OF LOAD | SPAN MOMENTS | | SUPPORT MOMENTS | |
|---|---|---|---|---|
| | Near middle span | At middle of interior span | At support next to the end support | At other interior supports |
| Dead load + Imposed load (fixed) | + 1/12 | +1/24 | - 1/10 | - 1/12 |
| Imposed load (not fixed) | +1/10 | +1/12 | - 1/9 | - 1/9 |
| For obtaining the bending moment, the coefficient is multiplied by the total design load and effective span. | | | | |

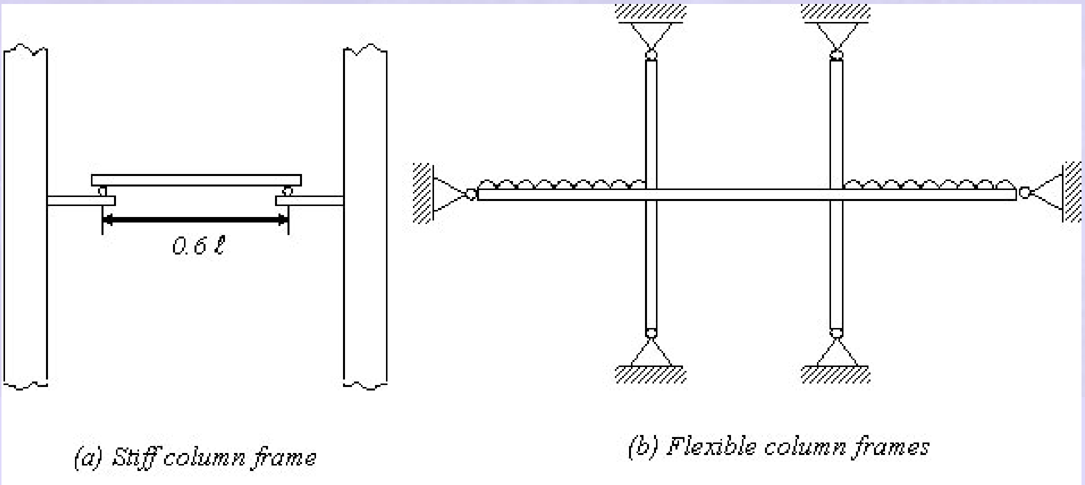


**Fig.3.9 Substitute models for analysis of frames**

**Table 3.3: Shear force coefficients**

| TYPE OF LOAD | At end support | At support next to the end support | | At all other interior supports |
|---|---|---|---|---|
| | | Outer side | Inner side | |
| Dead load + Imposed load(fixed) | 0.40 | 0.60 | 0.55 | 0.50 |
| Imposed load(not fixed) | 0.45 | 0.60 | 0.60 | 0.60 |
| For obtaining the shear force, the coefficient is multiplied by the total design load | | | | |

## Drift in Rigid Frames

The lateral displacement of rigid frames subjected to horizontal loads is due to the following three modes:

- Girder Flexure
- Column Flexure
- Axial deformation of columns

The sum of the storey drifts from the base upward gives the drift at any level and the storey drifts can be calculated from summing up the contributions of all the three modes discussed earlier in that particular storey. If the total drift or storey drift exceeds the limiting value then member sizes should be increased to avoid excessive drift.