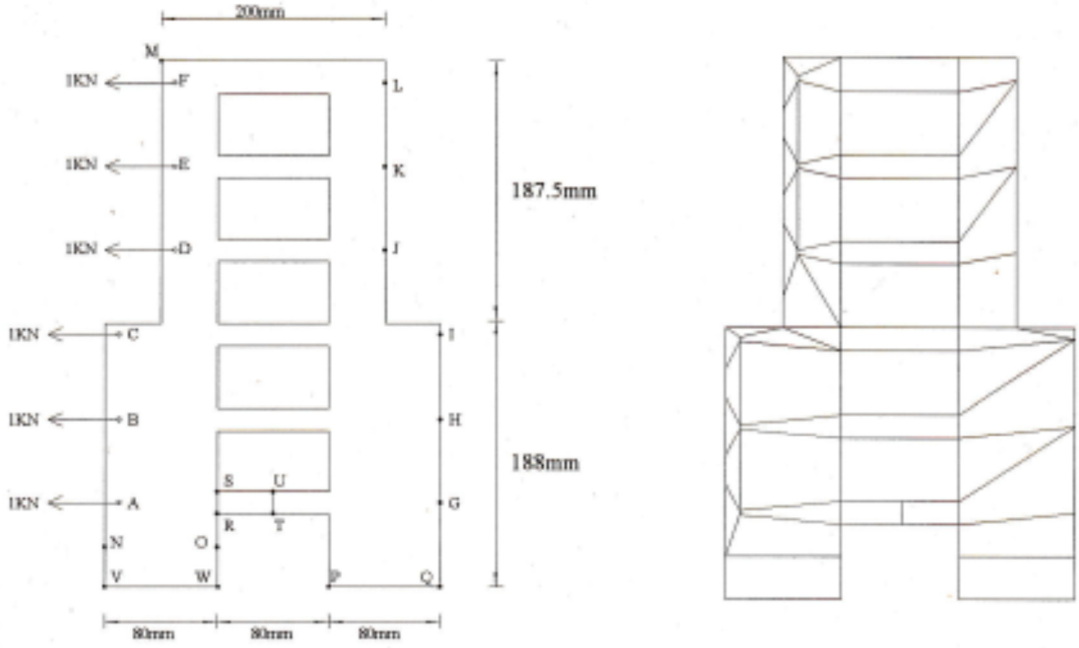
FINITE ELEMENT ANALYSIS OF A MULTI-STOREY BUILDING

The problem to be analysed is shown in Figure 1(a).



(a) Geometry & Boundary Conditions (b) Finite Element Mesh

Figure 1: The problem

The geometry is symmetric about a vertical plane and the main dimensions are as shown. The floors have centres at 60mm pitch and are 16mm thick. The only exception to this is the roof thickness which is 23.5mm. The loading positions (A,B,...,F) are located 10mm into the model on the floor centre lines.

The applied loads are of 20N at each of the six loading positions and the model is fully built-in along the edges V-W and P-Q. The material properties are $E = 3700\ N/mm^2$ and $\nu = 0.36$, the thickness is $t = 9mm$ and a plane stress constitutive relationship is used.

Of interest in this analysis are the displacements at the mid-floor positions along the unloaded edge (i.e. points G-L). An additional point M has been included since this appears to be the point exhibiting the maximum displacement. In terms of stresses, the direct stress in the vertical direction along line N-O will be evaluated and the direct stress in the horizontal direction along line R-S and the shear stress along the line T-U will also be determined.

The finite element mesh used for this problem is shown in Figure 1(b). The 'point' loads are modelled as distributed loads acting over a small 3mm length. Although the geometry is symmetric, the loading is not and, therefore, a full model is analysed. Node points are positioned at the points where displacements are to be monitored and the lines along which stress distributions are to be determined are modelled with a single element edge so as to enforce continuity of stress.

The results presented overleaf are for the load case described above i.e. 6 point loads each of 20N. If the experimental loads are not as great as this then the results presented here may be scaled pro-rata provided that the load pattern is preserved.

Results: displacements

The finite element results presented in this section are for the mesh shown in Figure 1(b) with fourth degree polynomial approximation of the internal stress field and boundary displacements. Convergence tests have shown that these results are sufficiently accurate for the purpose of this exercise and this can be confirmed, at least qualitatively, by the continuity exhibited in the displaced shape shown in Figure 2.

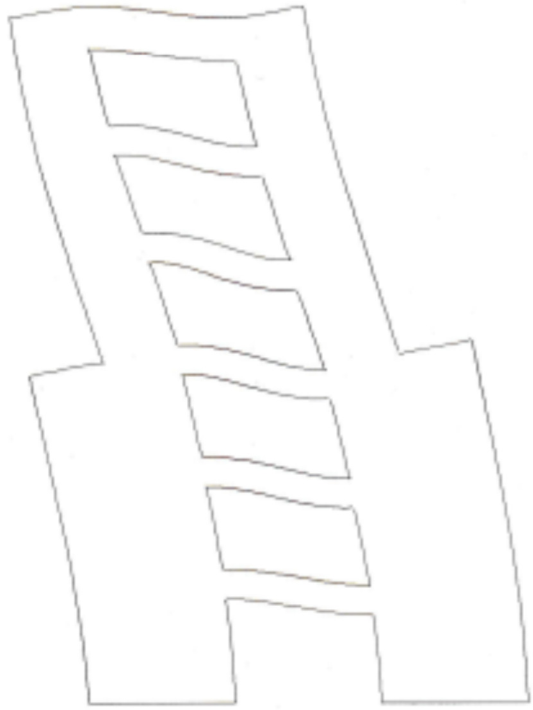


Figure 2: Displaced shape (scale = 500 times)

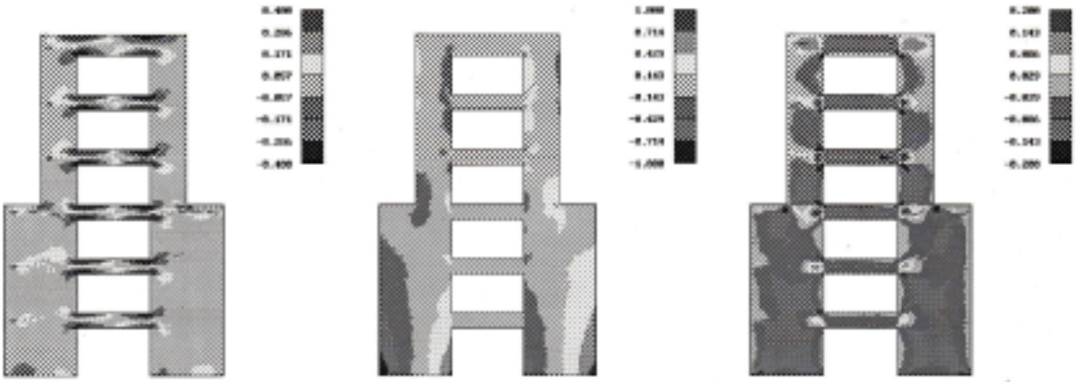
The displacements at the points of interest are given in Table 1.

Point	G	H	I	J	K	L	M
Displacement (mm)	-0.012	-0.034	-0.059	-0.098	-0.136	-0.168	-0.169

Table 1: Point displacements

Results: stresses

The three components of stress are shown in Figure 3. The x-direction is taken parallel to the horizontal. It should be pointed out that the stresses produced by the equilibrium elements used in this analysis produce stresses that are in equilibrium at every point. Hence, for example, it is seen that on all edges except those that have been restrained, the shear stress is zero.



σ_x - component σ_y - component τ_{xy} - component

Figure 3: Stress distributions

The distribution of direct stress in the y-direction along the line N-O is shown in Figure 4.

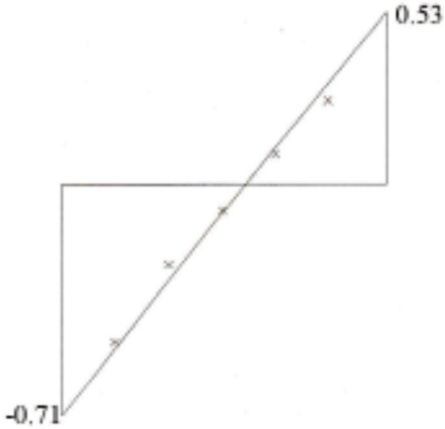
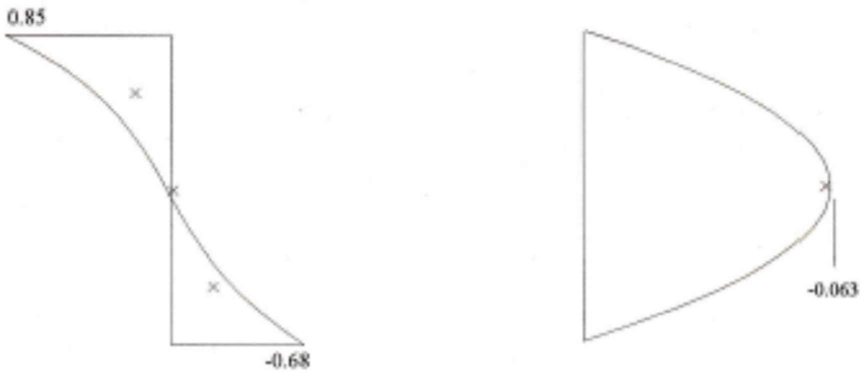


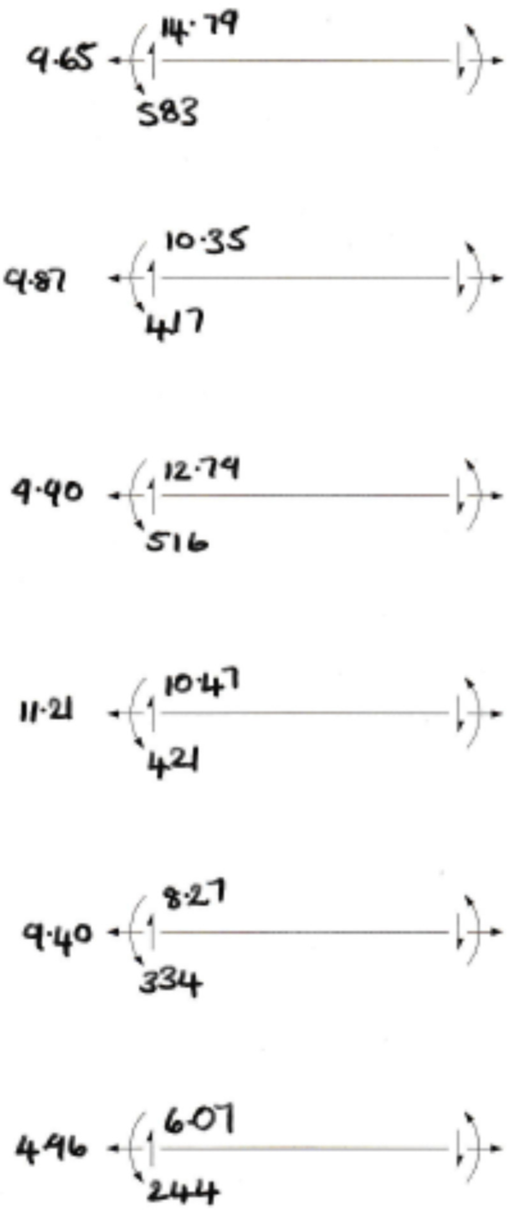
Figure 4: Normal stress along line N-O

Figure 5 shows the distribution of direct stress normal to the line R-S and of the shear stress tangential to the line T-U.

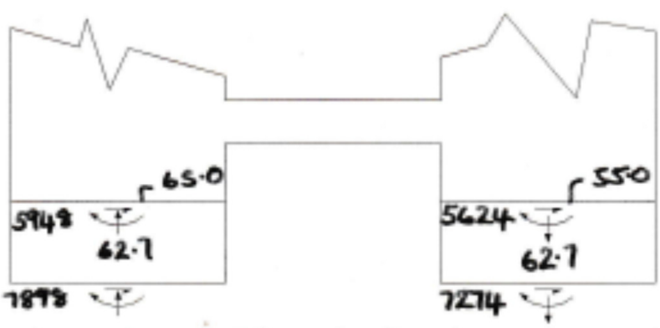


(a) Direct stress normal to line R-S (b) Shear stress tangentiall to line T-U

Figure 5: Stress distributions of interest

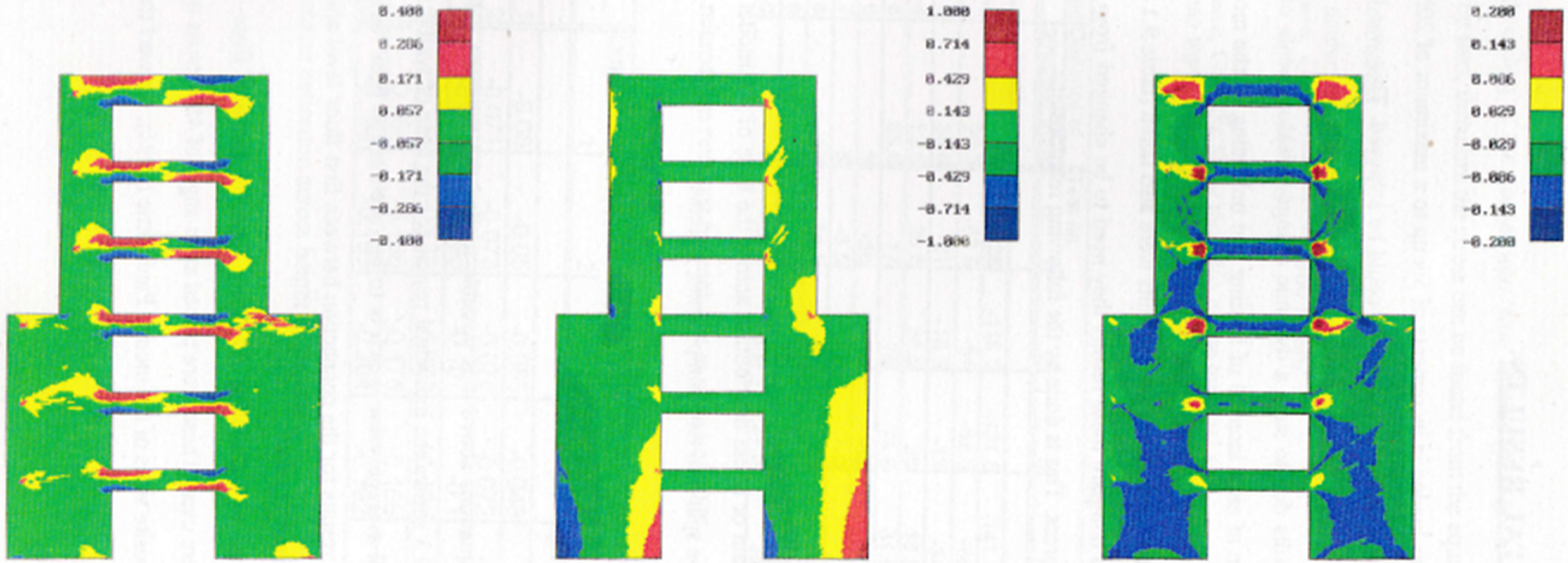


(a) Stress resultants at ends of ceilings



(b) Stress resultants at base of building and on line where strains are to be measured

Figure 6. Stress resultants along selected edges



σ_x - component σ_y - component τ_{xy} - component

Fig. 8.3 - Stress Distributions