Column Strengthening

Richard Henderson of the SCI discusses some of the issues

Columns in buildings are provided to carry axial loads in compression and, unless very squat, are designed so that their flexural buckling resistance exceeds the design load. The axial resistance of columns designed for buckling can be increased by either adding material so as to increase the section properties or providing restraints to reduce the effective length of the column, thereby reducing the slenderness and increasing the flexural buckling resistance (see reference i). For example, if a column can be restrained at mid-storey height such that its system length is halved, the critical (Euler) buckling load of the column N_{cr} is increased by a factor of 4. The flexural buckling resistance is increased by a factor which varies with slenderness from only about 13% for a very short, heavy column to 340% for a very slender column as examination of the "Blue Book" table for UC sections shows. Where the slenderness of a column is toward the lower end of this range, adding material is probably a more effective strategy.

The non-dimensional slenderness of a column is inversely proportional to the radius of gyration *i* about the relevant axis as indicated in para. 6.3.1.3 of BS EN 1993-1-1:2005:

$$\bar{\lambda} = \sqrt{\frac{Af_y}{N_{cr}}} = \frac{L}{\pi}\sqrt{\frac{f_y}{E}}\frac{1}{i}$$

Material added is the most effective when it is as far as possible from the centroidal axis of the column.

When load carrying columns are strengthened by adding material, the load shared by the original and additional material is the additional load applied after the strengthening work has been completed. Axial stresses in the original column material are increased by a stress equal to the new load divided by the total area. Axial stress in the new material is equal to the increase in stress.

At stage 1 (strengthening) the stress in original column: $\sigma_1 = \frac{N_1}{A_1}$; the stress in the additional material (Area A_2) is zero.

At stage 2 (in service), the load in the strengthened column is $N_1 + N_2$. The axial stress due to the new load is $\sigma_2 = \frac{N_2}{A_1 + A_2}$. The stress in the new material is σ_2. The stress in the original column is $\sigma_1 + \sigma_2$; the load in the new material is $N_{new} = A_2\,\sigma_2$.

The connection between the additional material and the original column has to be designed to transfer the axial load N_{new}. If the strengthening material is discontinuous at beam joints and a cross section check shows the original column resistance is adequate, the additional load has to transfer back into the original column section. The weld between the original and new material can be sized to transfer the load N_{new} over a short length and a smaller weld can be used over the remaining length to restrain the additional material from buckling under the load N_{new}.

One of the columns that was strengthened at 1 Triton Square

i: Strengthening existing steelwork, January 2019, New Steel Construction