4.8. Geometry as variable

In method 1, only the member sizes were treated as variables whereas the geometry was assumed as fixed. Method 2 treats the geometry also as a variable and gets the most preferred geometry. The geometry developed by the computer results in the minimum weight of space frame for any practically acceptable configuration. For solutions, since a iterative procedure is adopted for the optimum structural design, it is obvious that the use of a computer is essential.

The algorithm used for optimum structural design is similar to that given by Samuel L. Lipson which presumes that an initial feasible configuration is available for the structure. The structure is divided into a number of groups and the externally applied loadings are obtained. For the given configuration, the upper limits and the lower limits on the design variables, namely the joint coordinates are fixed. Then (k-1) new configurations are generated randomly as

$X_{ij} = 1_i + r_{ij} (u_i - 1_i)$

$i = 1,2,...n$

$j = 1,2,...k$

where k is the total number of configurations in the complex, usually larger than (n+1) where n is the number of design variables and r_{ij} is the random number for the i^{th} coordinates of the j^{th} points, the random numbers having a uniform distribution over the interval 10 to 1 u_i is the upper limit and 1_i is the lower limit of the i^{th} independent variable.

Thus, the complex containing k number of feasible solutions is generated and all these configurations will satisfy the explicit constraints, namely, the upper and lower bounds on the design variables. Next, for all these k configurations, analysis and fully stressed designs are carried out and their corresponding total weights determined. Since the fully stressed design concept is an economical and practical design, it is used for steel area optimization. Every area optimisation problem is associated with more than one analysis and design. For the analysis of the truss, the matrix method has been used. Therefore, the entire generated configuration also satisfy the implicity constraints, namely, the allowable stress constraints.

From the value of he objective function (total weight of the structure) of k configurations, the vector which yield the maximum weight is search and discarded, and the centrid c of each joint of the k-1 configurations is determined from.

$$X_{ie} = \frac{1}{K-1}\left\{ \sum_{j-1}^{K} \left(x_{ij} \right) - x_{iw} \right\}$$

i = 1, 2, 3.........n

In which x_{ie} and x_{iw} are the i_{th} coordinates of the centroid c and the discarded point ω.

Then a new point is generated by reflecting the worst point through the centroid, x_{ie}.

That is, $x_{iw} = x_{ie} + a\,(x_{ie} - x_{iw})$

i = 1,2,.......n

where α is a constant.

This new point is first examined to satisfy the explicity constraints. If it exceeds the upper or lower bound value, then the value is taken as the corresponding limiting value, namely, the upper or lower bound. Now the area optimisation is carried out for the newly generated configuration and if the functional value is better than the second worst, the point is accepted as an improvement and the process of developing the new configuration is repeated as mentioned earlier. Otherwise, the newly generated point is moved halfway toward the centroid of the remaining points and the area optimisation is repeated for the new configuration,. This process is repeated over a fixed number of iterations and the end of every iteration, the weight and the corresponding configuration are printed out, which will shown the minimum weight achievable within the limits (u_i and 1_i) of the configuration.