ABSTRACT

Reinforced cement concrete wall panels are load bearing integral structural elements of a building system. The conventional wall panels are heavy, reinforced at least with minimum percentage of compression steel and possess handling and erection problems. Thin-walled reinforced concrete wall panels may eliminate the above shortcomings of the conventional wall panels. They are also highly suitable for modern construction as well as economical. A thin-walled open section compression member may be a suitable alternative to the rectangular thin wall panels to overcome the stability problems. Various geometrical sections like channel, trapezoidal and curved sections can be used in place of conventional wall panels. By virtue of their geometrical shape, the slenderness effect, hence the stability problem can be minimised if not completely eliminated.

The main objective of the investigation is to study the behaviour of reinforced concrete thin-walled open section compression members with web stiffener in terms of load bearing capacity, lateral deflection and failure mode and formulate suitable design equations if the existing popular equations are not compatible. Regression analysis based on experimental data is carried out to suggest minimal changes to the existing design equations of IS 456 – 2000 and ACI 318 – 1989. The entire study is carried out in four phases.
In the first phase of investigation, literature survey was carried out covering the analytical and experimental works so far conducted in the area of the research. A critical review of the published literature indicates that research work available on thin-walled compression members is only related to steel and research on reinforced concrete thin-walled compression members is few. Moreover no literature is available on reinforced concrete thin-walled open section compression members with web stiffener. However, review of published literature in the area of the investigation either in reinforced concrete or otherwise was taken up to identify the parameters of investigation.

In the second phase of investigation, test specimens were cast. Forty-eighty numbers of channel section specimens and thirty-six numbers of trapezoidal section specimens were cast. The height, wall thickness, flange width and web width of the test specimens were varied to effect the change in the behaviour and load bearing capacity. All the test specimens were tested to failure in loading frames. First crack load, lateral deflection, failure load and failure mode were studied. The modes of failure were identified as torsional-flexural failure and flexural failure.

In the third phase, the effect of vertical web stiffener, increase in wall thickness, slenderness ratio and height to flange width ratio were examined and quantified in terms of lateral deflection, first crack load, failure load, stiffness and ductility factors. A series of graphs were drawn to illustrate the influence of above parameters. It is observed that torsional flexural failure takes place in channel specimens with slenderness ratio less than 40 and
beyond which flexural failure takes place. The same limit in case of trapezoidal specimens found to be 30. The above limit in case of height to flange width ratio is 12 and 10 for channel and trapezoidal specimens respectively. The web stiffener provided has significantly enhanced the ultimate load in all the four series of test specimens, but its contribution is influenced by the slenderness ratio and height to flange width ratio. The contribution of web stiffener in reducing the ultimate lateral deflection is quite effective but again highly influenced by the above two parameters. The experimental data of one third number of specimens were used for validation purpose.

In the fourth phase, comparison of the experimental failure load was made with the existing equations of concrete wall design. Their compatibility to the types of open sections tested has been evaluated. Due to lack of compatibility and inconsistent estimation of failure load in different ranges of slenderness ratio, it was decided to formulate an empirical expression for open section compression members without altering the basic form of existing referred equations. The strength ratio degradation of test specimens with increase in slenderness ratio is the basis on which the empirical equation is formulated. The validity of the proposed empirical equation for other type of specimens has been established using validation tests data. In the second stage of this phase, regression analysis of channel and trapezoidal specimens data have been carried out using two exclusive PSO programmes written in MATLAB to suggest minimal modification to the existing IS 456 – 2000 and ACI – 318 concrete column/wall formulae.
Suitable buckling factors were identified, optimised and incorporated in the above formulae without altering the present form of these equations. The compatibility of the modified IS and ACI expressions has been tested for channel and trapezoidal specimens and found to be satisfactory. Finally, comparison of theoretical ultimate loads of empirical equation, modified ACI precast wall equation and IS 456 – 2000 short column equation were made. In order to simplify the modified IS short column, buckling coefficient for channel and trapezoidal sections have been computed. All the three proposed equations are simple to use and yield reliable estimation of ultimate load. Out of the three suggested equations, the proposed empirical equation is the most reliable, very simple to use with buckling coefficient and nominally conservative in estimating the ultimate failure load. The maximum limits of slenderness ratio, height to flange width ratio, height to thickness ratio and web width to flange width ratio are suggested to exploit the section efficiency and material strength effectively.