DYNAMIC BEHAVIOR OF COMPOSITE BEAM WITH DIFFERENT CROSS SECTION

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Abstract:-The use of composite materials in various fields of civil engineering construction such as Building, Bridge, and other high performance engineering applications because of composite material are light in weight, having high performance material, strength material and stiffness. The construction using composite material is easy. This system is also created in MATLAB environmental to study various impact factors. The impact factor of various parameters on cross section of beam and different boundary condition of the beam and the effect of the length of beam. The study deals with the free vibration of laminated composite beam, Two-node finite element of three degrees of freedom and rectangular section are the free vibration analysis of the laminated composite beam.

Keywords: - Composite, Vibration, laminated, Beam

1. INTRODUCTION

1.1 General

In conventional composite construction, concrete slabs rest over steel beams and are supported by them. Under load these two components act independently and a relative slip occurs at the interface if there is no connection between them. With the help of a deliberate and appropriate connection provided between the beam and the concrete slab, the slip between them can be eliminated. In this case the steel beam and the slab act as a "***composite beam"*** and their action is similar to that of a monolithic Tee beam. Though steel and concrete are the most commonly used materials for composite beams, other materials such as pre-stressed concrete and timber can also be used. Concrete is stronger in compression than in tension, and steel is susceptible to buckling in compression. By the composite action between the two, we can utilise their respective advantages to the fullest extent. Generally in steel-concrete composite beams, steel beams are integrally connected to prefabricated or cast in situ reinforced concrete slabs

2. ELASTIC BEHAVIOUR OF COMPOSITE BEAMS

The behaviour of composite beams under transverse loading is best illustrated by using two identical beams, each having a cross section of $b\times h$and spanning a distance of λ, one placed at the top of the other. The beams support a uniformly distributed load of *w*/unit length as shown in Fig 1. For theoretical explanation, two extreme cases of no interaction and 100% (full) interaction are analyzed below:

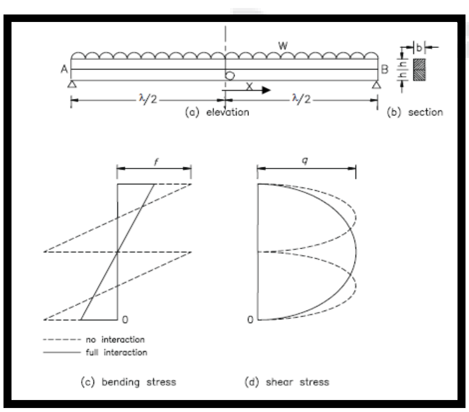

Fig. 1. Effect of shear connection on bending and shear stresses

2.1 No Interaction Case

It is first assumed that there is no shear connection between the beams, so that they are just seated on one another but act independently. The moment of inertia *(I)* of each beam is given by $bh^3/12$. The load carried by each beam is *w/2* per unit length, with mid span moment of $w\lambda^2/16$ and vertical compressive stress of *w/2b* at the interface. From elementary beam theory, the maximum bending stress in each beam is given by,

$$f = \frac{My_{max}}{I} = \frac{3w\lambda^2}{8bh^2}$$

where, *M* is the maximum bending moment and y_{max} is the distance to the extreme fibre equal to *h/2*.

The maximum shear stress (q_{max}) *that* occurs at the neutral axis of each member near support is given by

$$q_{max} = \frac{3}{2}\frac{w\lambda}{4}\frac{1}{bh} = \frac{3w\lambda}{8bh}$$

and the maximum deflection is given by

$$\delta = \frac{5(w/2)\lambda^4}{384EI} = \frac{5w\lambda^4}{64Ebh^3}$$

The bending moment in each beam at a distance *x* from mid span is,

$$M_x = w(\lambda^2 - 4x^2)/16$$

So, the tensile strain at the bottom fibre of the upper beam and the compression stress at the top fibre of the lower beam is,

$$\varepsilon_x = \frac{My_{max}}{EI} = \frac{3w(\lambda^2 - 4x^2)}{8Ebh^2}$$

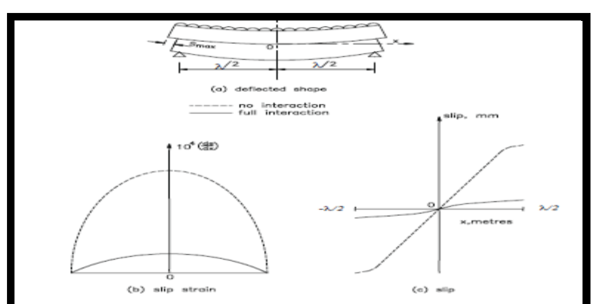

Fig. 2. Typical Deflections, slip strain and slip.

Hence the top fibre of the bottom beam undergoes slip relative to the bottom fibre of the top beam. The slip strain i.e. the relative displacement between adjacent fibres is therefore $2x\varepsilon$. Denoting slip by *S*, we get,

$$\frac{dS}{dx} = 2\varepsilon_x = \frac{3w\,(\lambda^2 - 4x^2)}{4Ebh^2}$$

Integrating and applying the symmetry boundary condition *S = 0* at *x* = 0 we get the equation

$$S = \frac{w\,(3\lambda^2 x - 4x^3)}{4Ebh^2}$$

The Eqn. (6) and Eqn. (7) show that at *x = 0*, slip strain is maximum whereas the slip is zero, and at *x=λ/2*, slip is maximum whereas slip strain is zero. This is illustrated in Fig 2. The maximum slip (i.e. $S_{max} = w\lambda^3/4Ebh^2$) works out to be *3.2h/λ* times the maximum deflection of each beam derived earlier. If λ */(2h)* of beams is *20*, the slip value obtained is *0.08* times the maximum deflection. This shows that slip is a very small in comparison to deflection of beam. In order to prevent slip between the two beams at the interface and ensure bending strain compatibility shear connectors are frequently used. Since the slip at the interface is small these shear connections, for full composite action, have to be very stiff.

2.2 Full (100%) interaction case

Let us now assume that the beams are joined together by infinitely stiff shear connection along the face *AB* in Fig. 1. As slip and slip strain are now zero everywhere, this case is called *"full interaction"*. In this case the depth of the composite beam is *2h* with a breadth *b*, so that $I = 2bh^3/3$. The mid-span moment is $w\lambda^2/8$. The maximum bending stress is given by

$$f_{max} = \frac{My_{max}}{I} = \frac{w\lambda^2}{8}\,\frac{3}{2bh^3}\,h = \frac{3w\lambda^2}{16bh^2}$$

This value is half of the bending stress given by Eqn. (1) for *"no interaction case"*. The maximum shear stress q_{max} remains unaltered but occurs at mid depth. The mid span deflection is

$$\delta = \frac{5w\lambda^4}{256Ebh^3}$$

This value of deflection is one fourth of that of the value obtained from Eqn. (3).

Thus by providing full shear connection between slab and beam, the strength and stiffness of the system can be significantly increased, even though the material consumption is essentially the same.

The shear stress at the interface is

$$V_x = q_x b = \frac{3wx}{4h}$$

where*x* is measured from the centre of the span. Fig.3 shows the variation of the shear stress. The design of the connectors has to be adequate to sustain the shear stress. In elastic design, connections are provided at varying spacing normally known as *"triangular spacing"*. In this case the spacing works out to be

$$S = \frac{4Ph}{3wx}$$

where, *P* is the design shear resistance of a connector.

The total shear force in a half of the span is

$$V = \int_0^{\lambda/2} \frac{3wx}{4h}\,dx = \frac{3w\lambda^2}{32h}$$

With a value of *λ/(2h)≈ 20*, the total shear in the whole span works out to be

$$2V = 2 \times \frac{3}{32}\frac{\lambda}{h}\,w\lambda \approx 8w\lambda$$

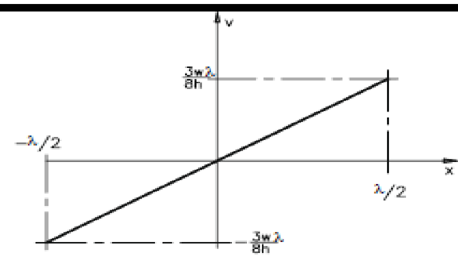

Fig.3. Shear stress variation over span length

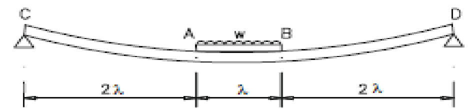

Fig. 4. Uplift forces

Vertical separation between the members occurs, if the loading is applied at the lower edge of the beam. Besides, the torsional stiffness of reinforced concrete slab forming flanges of the composite beam and tri-axial state of stress in the vicinity of shear connector also tend to cause uplift at the interface. Consider a composite beam with partially completed flange or a non-uniform section as in Fig 4. *AB* is supported on *CD*, without any connection between them and carries a uniformly distributed load of magnitude *w*. If the flexural rigidity of *AB* is larger even by *10%* than that of *CD*, the whole load on *AB* is transferred to *CD* at *A* and *B* with a separation of the beams between these two points. If *AB* was connected to *CD*, there will be uplift forces at mid span. This shows that shear connectors are to be designed to give resistance to slip as well as uplift.

CONCLUSION

- By using coposte material the structure should be light in weigth
- The natural frequencies of different boundary conditions of composite beam have been reported. The program result shows in general a good agreement with the existing literature.[1]
- It is found that natural frequency is minimum for clamped –free supported beam and maximum for clamped-clamped supported beam.[2]

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