Beam section height and different bearing on the deflection and stress effect

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Abstract. In this paper, the large-scale general finite element analysis software SAP2000 to establish a double span continuous beam finite element model, using a Stepwise analysis finite element method to analysis on the same cross section width and span, Different types of bearing and the beam section height change deflection and stress .Research results show that beam height achieves a certain height that deflection and stress tend to be stable, The change is not obvious. The results of their research is for the structure design of reinforced concrete beam, Static and dynamic analysis to provide reference.

Introduction

We shoud control the deflection of the beam in the structure design, Meet the component deformation requirements to limit beam deflection .controled the stress of limited value to make the concrete not being crushed, So we guarantee a beam compression zone of concrete damaged steel beam reaches the yield that let beam happen plastic damage. Stress and deflection of the beam is an important controled factor,

Stress and deflection of the beam is an important controled factor, So this paper analyzes the two, with the beam height increasing, Studying the change of deflection, The results show that when the beam is up to a certain height deflection and stress tends to be stable and to not have bigger change. However in the change of bearing type, Stress and deflection also have varying degrees of change, It also shows that we can use bearing to change the numerical value of the stress and deflection in the structural design .

In conclusion, the beam structure design and calculation analysis of the deflection of the beam must be checked and stress variation. This paper takes double span concrete beam as an example, through the large-scale finite element analysis software Sap2000 to establish the finite element model of the beam, the beam concrete beam change high and bearing on its deflection and stress changes. At the same time for other similar beam after the structure design and calculation of static and dynamic analysis provides the important reference role.

Deflection and stress in the concrete structure beam in the theory of computation

1) According to unit force method of the structural mechanics ,the displacement of Static elastic structure can be expressed as under the action of load :

$$\Delta = \sum \int \frac{N\bar{N}ds}{EA} + \sum \int \frac{M\bar{M}ds}{EI} + \sum \int k \frac{V\bar{V}ds}{GA} \quad (1)$$

The formula can be seen that major displacement changes are with about load and displacement of beam .This paper is to consider the beam width under the condition of constant beam high variation on displacement beam deflection effects.

2) The pure bending stress calculation formula: $\sigma = \frac{My}{Iz}$ (2)

M-The cross section of the bending moment; Y-The stress to the neutral axis distance;Iz- section

to the neutral axis of moment of inertia.

This calculation method is what we mean by analytic method. Beam unit is actually the body unit, If using analytic method to calculate, It is necessary to simplify the structure, While these simplified and practical structure often exist certain difference, In some circumstances, These differences will give structure analysis results have not allowed error, And the finite element method can get more accurate results, This paper uses the finite element method for solving.

Step increment method in the finite element application

Step increment method is a calculation method, a known amount divided into several equal parts, the nonlinear equation group as linear equations, piecewise linear solution, then the obtained result gradually accumulated. Step increment method is essentially a piecewise linearization method, that is finite element analysis solving method. Nonlinear types in the component analysis of force often encounter the nonlinear problem which is broadly divided into two categories: one category is geometrically nonlinear problem, another kind is the material nonlinear problems, or a class two have both at the same time. Duing to the structure of nodal displacement, Geometrically nonlinear problems is quite large, that must be in accordance with the deformed geometry to establish equilibrium equation. As a result of geometric location after deformation unknown, this gives processing geometric nonlinear problems in certain complexity. Its essence is that the structural member in stress deflection changes is divided into several small unit connected to each other in the whole process of stress deflection changes, assumed to be flat in each small unit , obtained a small plane point stress and deflection increment. Then according to the allowable conditions, we can obtain stress and deflection variation of the small unit , thus obtain stress and deflection variation of each partitioned unit under the same conditions ,In the whole process of calculation and analysis , dividing the unit is smaller and finer, the calculation accuracy is higher. The beam height and the deflection change analysis are using incremental method.

Engineering Examples

Engineering survey

Based the double span continuous beam of the different bearing types and different beam height as an example, analyzing deflection and stress variation .The double span continuous beam span is 6m, Section width is 0.3m, the distributed load is 5kN/m.When the beam is respectively hinge, fix, the column and section height is 450mm, 600mm, 900mm, 1200mm, 1500mm, 1800mm, 2000mm ,three section stress and deflection of the size are changing, And compare among these variables changes on the stress and deflection effect. Model diagram as shown in figure 1- figure 3.

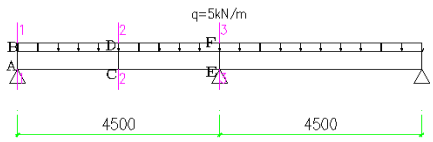

Figure 1: the articulated model diagram of bearing

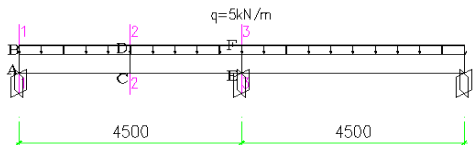

Figure 2: fixed connection diagram

Finite element model

In this paper, using the universal finite element analysis software SAP2000V14.2.4 build the finite element model of double span continuous beam, And three sections are as the main research object. In finite element analysis, Every cross is divided into 10 bodies unit, When the beam is articulated, the beam is in 450mm, 600mm, 900mm, 1200mm, 1500mm, 1800mm, 2000mm ,the stress and deflection is changing in A and B, C and D, E and F point of 1-1,2-2, 3-3 section .When the beam is all fixed and bearing are all columns (pillars of section 500mmX500mm, column height is 4m,end of beam is fixed, the middle of the beam is hinged), the same analysis above several section height A, B, C, D, E, F point stress and deflection size.

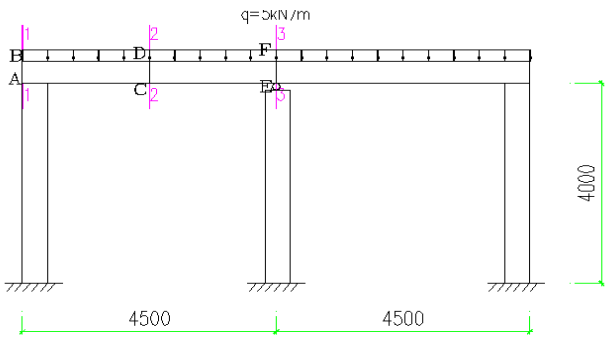

Figure 3: model diagram of bearing for the column

The results of finite element analysis

With the beam height increasing ,the stress is changing

Now stress analysis variation of select A, B, C , D, E, F represents the point , such as in Figure 3 to figure 6 (horizontal cross section height, unit: mm, the vertical axis is the stress value, unit: N/mm²) shown below.

bearing is articulated, load q=5kN/m

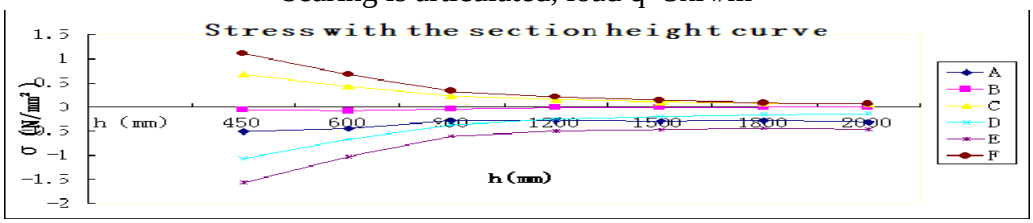

Figure 4: bearing is hinged ,the stress variation with altitude chart

bearing is fixied, load q=5kN/m

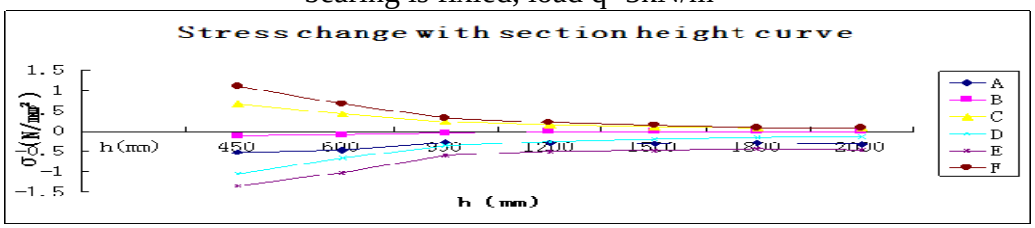

Figure 5: bearing is fixied ,the stress variation with altitude chart

bearing is all columns, end of beam is fixed, the middle of the beam is hinged,loadq=5kN/m

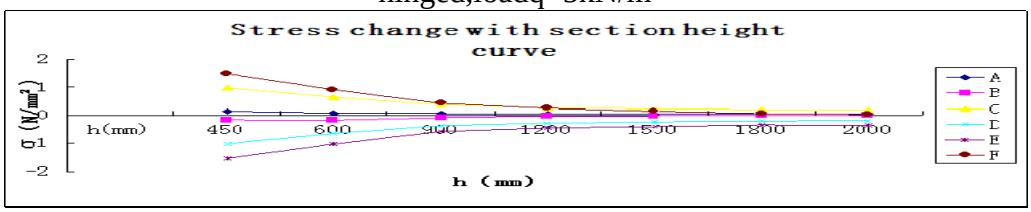

Figure 6: bearing for the pillars of the stress variation with altitude chart

Figure 4 - Fig. 6: the stress values, with the section height growth, decrease gradually, but in the section height of 900mm prior, the stress changes is rapidder and 900mm stress changes are slowly to stabilize; by the theory(2) that increasing the height of the cross section can be reduced stress size, it can be seen from the figure when beam is up to 900mm, stress changes are slowly to stabilize.

Different bearing stress changes

Now stress analysis variation of select A, B, C,D, E, F represents the point ,specifically as shown in Figure 7 (a horizontal axis is different representative point, the vertical axis is the stress value, unit: N/mm²) shown below.

The height of beam is 600mm, load q=5kN/m

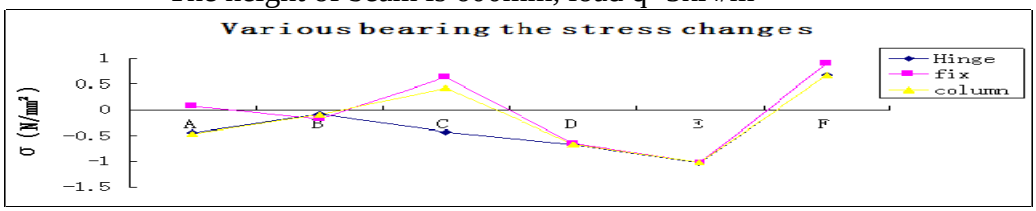

Figure 7: different bearing the stress change chart

Figure 7: When the bearing is hinge and pillar ,A visible stress is basically unchanged, when fixed connection ,stress direction happen changes and stress size is close to zero, the result indicates that the fixed bearings constraint A point and make the stress direction happen changes and stress size is small. B, D, E, F stress under different bearing conditions change little, but C point in the different bearing conditions have changed obviously, when the bearing is fixedly connected and pillars,the stress is compressive stress; bearing is hinged , the tensile stress. The comparison shows that the constraints influence on the A and C stress , but B, D, E, F stress effects are very small.

Different bearings, different beam height ,the deflection changes of the middle of the beam

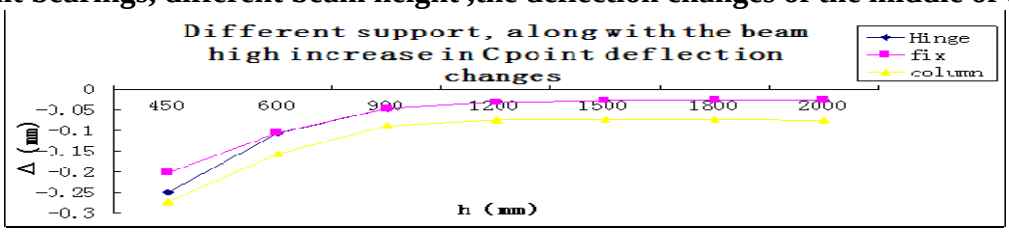

Figure 8: different bearings, different beam height C deflection change chart

Figure 8 visible: mid-span deflection value is incresing with the section height growth, the middle cross section of C deflection decreases gradually, by theory(1) the mid-span deflection influenced by the rigidity is large, so the gradually increased height make the deflection decrease . But when the section height is less than 900mm, C point deflection decreases rapidly, when the section height is greater than 900mm, mid-span deflection decreases smaller and tends to stable.

Beam bearing is hinged and fixed connection, when the beam height is 450mm, deflection of articulated is larger than that of fixed; after 600mm, deflection of hinged and fixed is basically the same, so when the height of beam is much smaller, constraint function can reduce the deflection of beams, when the height is much larger ,changing effect of fixed bearing is not obvious When the bearing is the column, hinged beam deflection is significantly greater than fixed beam deflection in C point. Because the bearing is column, the column elastic deformation caused the cross-beam deflection changes, which makes deflection of the column bearing is larger than that of hinged and fixed bearing.

Conclusions and Suggestions

First, beam section height influens on beam stress , with the beam section height increasing, the stress decreases; when the beam is up to 900mm, the change of stress tends to be stable. Therefore, within a certain range of beam height, stress influence is much lager. The height of beam is infinitly increased and stress reduces, which is not the economy in structure design .

Second, the middle section deflection is smaller when section height is increasing, and when the beam is up to 900mm, beam deflection tends to be stable. Therefore, unlimited increase of section height to reduce the middle deflection is not the economy in the structure design.

Third, different bearing is influened on deflection. the bearing is different ,which influen on much larger in the C point stress than other parts. the bearing is column, the column elastic deformation caused the cross-beam deflection changes, which makes deflection of the column bearing is larger than that of hinged and fixed bearing.

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