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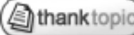
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Rayleigh frequency

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Author

sukanta.adhikari
General Sponsor



Joined: 26 Jan 2003
Posts: 706

Message

Posted: Mon May 30, 2011 6:21 am Post subject: Rayleigh frequency



Dear Sefians,

I am trying to understand Rayleigh frequency in detail.Could not find good literature on the same.

On going through NZS 1170 I could find the formula for calculating time period by Rayleigh method.

The equation for calculating Rayleigh frequency is dependent on **horizontal displacement,the magnitude of horizontal force**,weight of the structure and the number of storey.

My question is natural frequency of a structure is independent of the horizontal force...it is the function of mass and stiffness of structure...but the frequency calculation from Rayleigh method is dependent on the magnitude of horizontal force and the horizontal displacement of structure.

Can someone explain this.

Regards,
S.Adhikari

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suresh_sharma



Joined: 23 Mar 2011
Posts: 783

Posted: Mon May 30, 2011 8:15 am Post subject:



Dear Mr. Adhikari,

Like you, I am also trying to understand the Rayleigh frequency. It appears to me that you are very close to the correct understanding. The horizontal force that you have spoken to in your posting, according to me, is the weight of the structure applied in horizontal direction and the horizontal deflection of the joint resulting from the above horizontal load is to be accounted for.

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sukanta.adhikari
General Sponsor



Posted: Mon May 30, 2011 8:50 am Post subject:



Dear Suresh Sir,

Might be you are correct because when we calculate Rayleigh frequency in STAAD we only provide the mass of the structure.

Let us get one more conformation from expert's.

I have seen your profile.You have 35 years of experience in this field.Nice to see ur active



Joined: 26 Jan 2003
Posts: 706

participation in the forum.

Regards,
S.Adhikari

suresh_sharma wrote:

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Like you, I am also trying to understand the Rayleigh frequency. It appears to me that you are very close to the correct understanding. The horizontal force that you have spoken to in your posting, according to me, is the weight of the structure applied in horizontal direction and the horizontal deflection of the joint resulting from the above horizontal load is to be accounted for.

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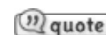
Radha krishna



Joined: 01 Nov 2008
Posts: 70



Posted: Mon May 30, 2011 12:13 pm Post subject:



Dear Adhikari,

Rayleigh frequency is the function of mass and stiffness (stiffness in the direction in which we are calculating frequency)

$T = 2\pi \sqrt{m/k}$ or (Δ/g)

what staad or other software does is applying the load in that particular direction and (say for example self weight in X) take the maximum deflection of the structure (say for example max X)

and calculates the rayleigh time period by using $T = 2\pi \sqrt{\Delta/g}$

that is the reason why we get higher time period in structures where we have flexible parts in structure like cantilever with less lateral stiffness, Even though whole structure is stiff

You can observe what staad help says.

From Staad: (for the command to calculate rayleigh frequency)

This command is based on the Rayleigh method of iteration using 1 iteration. The frequency calculated estimates the frequency as if the structure were constrained to vibrate in the static deflected shape generated by the loads in the load case.

In many instances, the forces should be in one global direction to get the mode and frequency associated with that direction.

Radha Krishna Gavarasana.

Last edited by Radha krishna on Mon May 30, 2011 12:33 pm; edited 1 time in total

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mrbabu77
SEFI Regulars



Joined: 21 Sep 2009
Posts: 29



Posted: Mon May 30, 2011 12:33 pm Post subject: Rayleigh's method for calculating natural frequency

Let me summarise my understanding on this.

Rayleigh's method derives natural frequency of a structure by equating potential energy and kinetic energy. Usually, potential energy and kinetic energy calculations are done by applying a force/s on the structure at discrete points. For a simple cantilever beam, the point could be at the tip of the cantilever and for a multi-story building; points could be at floor levels. For a distributed mass system, the concept can be applied by assuming discrete points on the structure.

Now, we look at the question of *horizontal force and displacement*- For any structural dynamic problem, the starting point is assuming a deflected curve (shape function) of the structure, and calculating velocity, acceleration and from acceleration the resulting force by applying Newton's second law of motion- $F = ma$. We are doing the same procedure in Rayleigh's method by equating potential energy and kinetic energy. However, the final answer of natural frequency is independent of *horizontal force and displacement*. It is just the formula that creates confusion.

Let me explain this further. Most codes provides formula of the type

Period $T = 2\pi \sqrt{\frac{w_1(y_1)^2 + w_2(y_2)^2 + \dots}{g(f_1 y_1 + f_2 y_2 + \dots)}}$

Where w_1, w_2 etc are effective seismic weights at discrete points (floor levels), f_1, f_2 etc are horizontal forces at discrete points and y_1, y_2 etc are corresponding displacement due to f_1, f_2 etc. and g is the acceleration due to gravity. The horizontal forces are derived from distributing base shear vertically.

Now, look at the basic equation for period $T = 2\pi \sqrt{m/k}$, where m is the effective mass and k is the effective stiffness of the structure. Note that, I have used the word *effective* because not all masses are participating in particular vibration modes. By comparison, we can see that, this is the same equation of time period by codes based on Rayleigh's method. Only difference is that $w=m/g$ is used in the code equations. Also remember that, how to calculate stiffness k ?-this done by applying forces at specified points-the forces could be any arbitrary value. From the basics we know that $k=P/y$ and above procedure is nothing more than applying fundamentals to solve substantially large systems with reasonable accuracy.

I hope, this clarifies the question.

Regards,

Babu M. Raghavan

Chartered Structural Engineer

Director

ENGCEPTS Engineering and Consultancy Pvt Ltd

Thrissur, Kerala



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manohar
SEFI Regulars
[4 empty boxes]

Joined: 26 Jan 2003
Posts: 23

Posted: Mon May 30, 2011 2:51 pm Post subject: Rayleigh frequency



Dear Adhikari

Here is my bit of explanation.

The Rayleigh's method provides a quick way to estimate the fundamental natural frequency starting with a crude approximation to the mode shape. For example, if an estimate of the fundamental natural frequency of a cantilever beam is required, one can use the deflected profile of the beam under self-weight as an approximation to the mode shape and arrive at an approximation to the first natural frequency using the expression $w = \sqrt{u^* K u / u^* M u}$ where u is the assumed mode shape, u^* its transpose, and K and M are the structure mass and stiffness matrices respectively. The assumed mode shape here satisfies the boundary conditions at the fixed end and at the free end and it is not a bad approximation to the first mode shape. I am not aware of the details of the Staad programme. The initial calculation is possibly being made to arrive at a guess on the mode shape.

The interesting thing about this method is that the true natural frequency would be always less than $\sqrt{u^* K u / u^* M u}$ for alternative choices of u . This would mean that between two alternative choices for u leading to two alternative values of w , the one which that leads to lesser w is to be accepted.

An intuitive explanation for this could be as follows: Imagine, two postures of a soldier: one standing-at-ease and the other standing-in-attention. Let the stand-at-ease posture be the true normal mode and stand-in-attention be an approximation. To stand in attention the soldier needs to stiffen his body which naturally leads to enhanced natural frequency. Similarly, any approximation to the mode shape that is different from the true mode shape, additional forces need to be applied to maintain the assumed shape. This would increase the potential energy of the system and hence increase the estimate of the natural frequency.

I hope this helps in your admirable desire to understand things.

Best regards

Manohar

[quote]Dear Adhikari,

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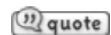
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sukanta.adhikari
General Sponsor



Joined: 26 Jan 2003
Posts: 706

Posted: Mon May 30, 2011 4:18 pm Post subject: Re: Rayleigh's method for calculating natural frequency



Dear Raghavan sir,

Thanks you very much for providing this crystal clear explanation on Rayleigh frequency.

Regards,
S.Adhikari

mrbabu77 wrote:

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Regards,

Babu M. Raghavan

Chartered Structural Engineer

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ENGCEPTS Engineering and Consultancy Pvt Ltd

Thrissur, Kerala

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sukanta.adhikari
General Sponsor



Joined: 26 Jan 2003
Posts: 706

[profile](#) [pm](#)

Posted: Tue May 31, 2011 4:59 am Post subject: Rayleigh frequency

[quote](#)

Respected Manohar Sir,

Thank you very much for the explanation on Rayleigh frequency. A year before also you have helped me in understanding mode shapes.

Regards,
S. Adhikari

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