Dynamic Calculation of Noise Barrier Subjected to Impulsive Wind Pressure Based on ANSYS

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Abstract. According to the noise barrier structures of high-velocity railway,the structural character was systematically analyzed．In this paper, the simulation calculation method is adopted to analyze the impulsive wind pressure acted on the noise barrier of inserted based on ANSYS software.Different influence factors, which include the velocity of trains and distance between upright columns, are considered to simulate the transient dynamic response of the noise barrier structure. The variation trend of response by the influence of different factors is obtained. In addition, the optimal range for the distance between upright columns is put forward.

Introduction

With the rapid development of railway construction in our country, traffic service becomes convenient , however, noise pollution along the railway line is increasingly serious at the same time. The noise barrier set up on both sides of railway lines is one of the main measures to reduce noise pollution , and it has been obviously used at home and abroad. At present, metallic noise barrier of inserted is mainstream in China and widely employed in the railway construction, this type in the total number of noise barrier accounted for more than 90%. Due to the increase of velocity of train, the influence of noise barrier structure caused by the impulsive wind pressure becomes more significant, only static loading analysis can not meet the practical requirements. In order to ensure the safety of the structure, the analysis of simulating the dynamic response for noise barrier structure subjected to impulsive wind pressure is necessary .

Pressure calculation

Pressure on the noise barrier structure include gravity, wind pressure and the impulsive wind pressure, which is caused by severe disturbance of the air nearby when high-velocity train passes by, the alternating positive and negative pressure wave are caused by the disturbance on the surface of noise barrier in the short time. Pressure wave increases obviously with the increase of train velocity. Therefore, the influence of impulsive wind pressure on noise barrier structure should be focused on , when the train run with the high velocity at approximately 350km/h. Researchers in Germany have made related online road test before, the German railway company have presented the curve for ICE3 (high-velocity train). Based on FE dynamic analysis,the impulsive wind pressure on the noise barrier can be expressed as Eq. 1.

$$q = c_p \cdot c_z \cdot r \cdot \frac{n^2}{2} \qquad (1)$$

Where q is the impulsive wind pressure (N/m^2) , c_P is the coefficient of impulsive wind pressure, c_z is the coefficient the height above the rail surface , r is the air density(kg/m^3), n is the train velocity(m/s).

FE model for noise barrier

In this paper, FE model for metallic noise barrier of inserted is established. According to the standard of noise barrier for railway engineering construction, metallic noise barrier of inserted includes H-Beam upright column, H-Beam baseplate, aluminum alloy elemental plate , rubber and so on. The size and the connection are shown in Fig 1.

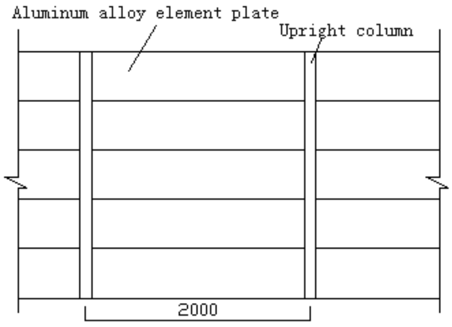


Fig 1. Size and Connection

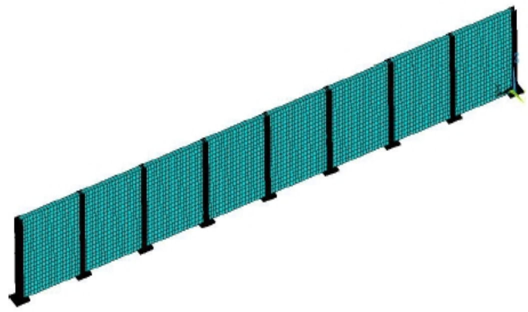


Fig 2. FE Model for Noise Barrier of Inserted

In order to analyze the dynamic response of noise barrier structures subjected to impulsive wind pressure, FE model is established for metallic noise barrier, which is 16m in length(8-span) and 2.15m in height. While solid45 entity unit is simulated for H-Beam upright column(HW$^{175\times175}$), shell 63 entity unit is simulated for aluminum alloy elemental plate($^{1950\times430\times140}$), the monotube rubber blanket between upright column and elemental plate is simulated by solid45 entity unit, which is connected to upright column by common node and connected to elemental plate by coupling constraint. Meanwhile, snap-fit connection is simulated for the connection of elemental plates. Bulge and groove are ignored, and damping factor is simulated for rubber. In addition, in order to show the modes of vibrations of aluminum alloy elemental plates better, the materials in noise barrier structures are ignored because of the little density of sound-insulation materials. FE model for noise barrier of inserted is shown in Fig 2 and parameters are given in Table 1.

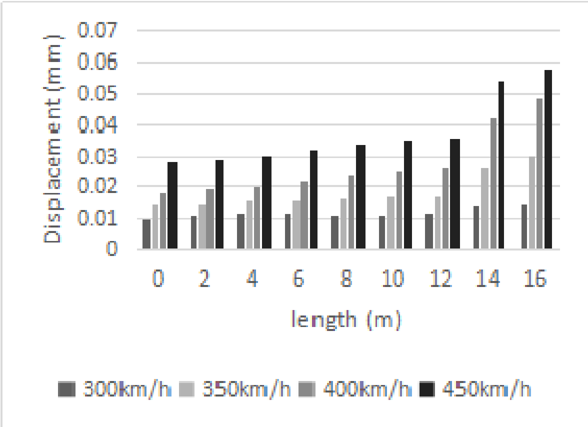
Table 1. Parameters for Noise Barrier Structure

Name of component	Type of element	Material	Density	Modulus of elasticity	Poisson ratio	Damping
H-Beam upright column	SOLID45	Carbon steel	7800	2.00E+05	0.274	0.002
Elemental plate	SHELL63	Aluminum alloy	2700	7.00E+04	0.3	1.00E-05
Rubber	SOLID45	Rubber	1230	3	0.32	0.1

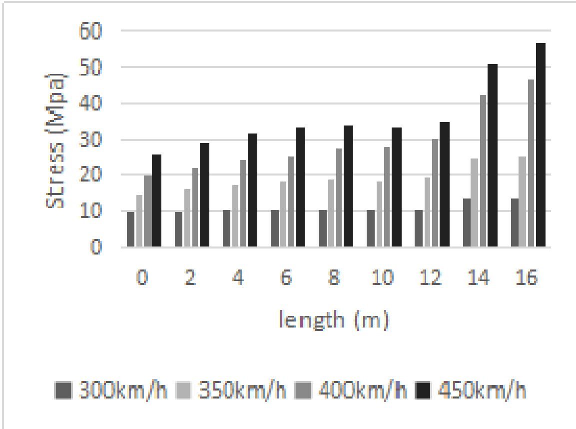
Analysis on transient dynamic response

Influence of train velocity

Upright columns should be analyzed,because upright columns are the weakest in the whole noise barrier of inserted structure. The dynamic response curve along the length of the noise barrier structure caused by CRH2 passing by is shown in Fig 3, as shown, the distribution of maximum displacement and maximum stress between upright columns are nearly the same,both of two first increase, then decrease and then increase along the length, until the last upright column would reach to maximum, the maximum displacement and the maximum stress of the penultimate and the last upright column vary remarkable. The maximum dynamic response of noise barrier structure subjected to impulsive wind pressure appears at the last upright column.



(a)Maximum Displacement



(b)Maximum Stress

Fig 3. Maximum Displacement and Maximum Stress between Upright Columns in Different Location

Maximum displacement and maximum stress between upright columns of the whole noise barrier structure caused by the train passing by at the velocity of 300km/h、350km/h、400km/h、450km/h is given in Table 2. The maximum displacement is 0.0132m and the maximum stress is 13.8Mpa at the velocity of 300km/h. as shown, the displacement and stress increase obviously with a nonlinear relationship with the increases of velocity of trains and distance of upright column.

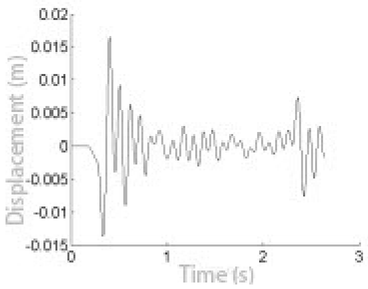
Table 2. Maximum Displacement and Maximum Stress between Upright Columns

Velocity (km/h)	300	350	400	450
Maximum displacement (m)	0.0132	0.0292	0.0484	0.0581
Maximum stress (Mpa)	13.8	30	47.2	57.3

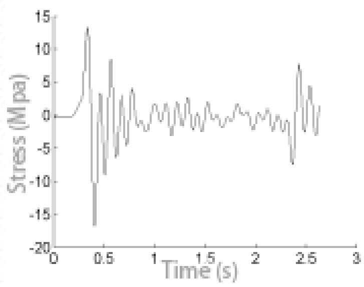
Influence of the distance between upright columns

In order to study the influence of the distance between upright columns on dynamic response of noise barrier of inserted, the dynamic response at the distance of 1m, 1.6m, 2m, 3.2m is analyzed. According to Equations 1, caused by the train passing by at the velocity of 300km/h, impulsive wind pressure curve of 16m long noise barrier structure of 5-span, 8-span, 10-span and 16-span is calculated.

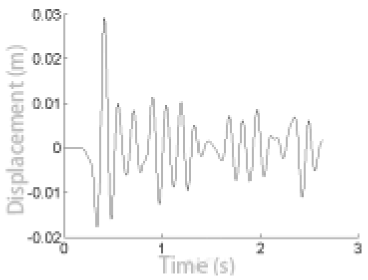
As shown in Fig 3, according to the analysis of the relationship between the response of upright column and the velocity of train in different location, both maximum displacement and maximum stress appear at the last upright column,which is the most unsteady. So this upright column(the last upright column) is chosen to analyze the influence of the distance between upright columns on dynamic response of noise barrier structure. The displacement and stress curve at the distance of 1m and 2m is shown in Fig 4.



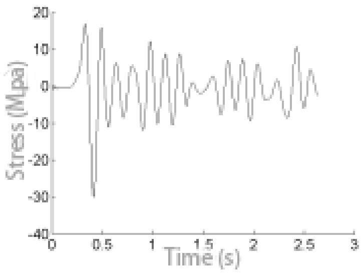
(a)Time Curve of Displacement at Distance of 1m



(b) Time Curve of Stress at Distance of 1m at Distance of 1m



(c) Time Curve of Displacement at Distance of 2m



(d) Time Curve of Stress at Distance of 1m at Distance of 2m

Fig 4. Time Curve of Displacement and Stress for Upright Columns at Different Distance

As shown in Fig 4,the variation of time curve of displacement, stress and impulsive wind pressure of the last upright column are nearly the same, the maximum value of response is caused by head wave, the minimum value is caused by intermediate wave, and the moderate value is caused by coda wave. The response caused by intermediate wave increases obviously with the increase of the distance between upright columns. When the distance between upright columns is 2 meters, the value of the response rise to peak several times, it has bad influence on the fatigue life of H-Beam upright column.

Table 3. Maximum Displacement and Maximum Stress at Different Distance between Upright Columns

Distance (m)	1	1.6	2	3.2
Maximum displacement (m)	0.0165	0.0239	0.0292	0.0374
Maximum stress (Mpa)	16.9	25.1	30	35.1

Considering the distance between upright columns, at the distance of 1m, 1.6m, 2m and 3.2m , the maximum displacement and the maximum stress of the last upright column is given in Table 3. The maximum displacement is 0.0165m and the maximum stress is 16.9Mpa at the distance of 1m , as shown, the displacement and stress of the last upright column increase with a nonlinear relationship with the increases of the distance between upright columns.

Conclusions

Both maximum displacement and maximum stress of upright columns, first increase, then decrease and then increase along the length, until the last upright column would reach to maximum, the maximum displacement and the maximum stress of the penultimate and the last upright column vary remarkable.Therefore, great attention should be paid to strengthen the noise barrier structure at the last upright columns and their adjacent upright columns.

Maximum displacement and maximum stress of all the upright columns increase with the increase of the velocity of train and the distance between upright columns, in nonlinear relation. Meanwhile, The response caused by intermediate wave increases obviously with the increase of the distance between upright columns, appearing several peak value, which has bad influence on the stability of the structure.

Acknowledgements

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