EFFECT OF CONCRETE BARRIERS WITH A LOAD STRIKE ANGLE

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Abstract- Concrete barriers are placed in districts where vehicles are prohibited to enter. In this study, the suggested section concept comprises three parts. The nonlinear explicit dynamic ANSYS finite element software is used to confirm the strike angle effect during impact force with different load magnitudes. Results demonstrate that the new shape can deal with the impact force with an appropriate strike angle. The deformations, stresses, and strains in the concrete part influenced by the applied load regularly vary with the increase in load strike angle. The strike angle of 20° is more sensitive than other strike angles.

Keywords- Concrete barrier, Strike angle, ANSYS software, Concept.

I. INTRODUCTION

Vehicle entrance is not permitted in some areas, such as slight medians, roadsides, and bridge sides, because serious accidents may occur, and thus concrete barriers are used to organize wayward vehicles [1], [2]. The specifications for roadside design criteria should be considered in the design of concrete barriers [3], [4]. The concrete barrier properties, such as their shape, height, width, length, and connection design, affect the main concept of the design for all types of concrete barriers used in different areas of the critical zone of roads and highways. Other parameters, such as vehicle speed, vehicle strike angle, and vehicle weight, also influence the design of concrete barriers and the test methods used to obtain the best design. To reduce the vehicle accident effect on individuals using roads and road facilities, which leads to great financial losses for road maintenance caused by these accidents [4], [5], the security of road users, car drivers, and pedestrians is important and a major difficulty in highways, streets, and intersection, especially in central business districts and large cities such as Kuala Lumpur. A good design of concrete barriers must stand the impact load exerted from vehicle collision. These barriers should not separate during accidents. The concrete barrier design in Malaysian highways remains an old one and does not change in shape or has not developed in its properties. A simple concrete barrier design and better construction are important to achieve good service for road customers. With the current concrete barriers in Malaysian highways, many drivers either die or become dangerously injured in vehicular accidents. These problems must be addressed in the design of concrete barriers to maintain the flow of vehicles in the right way and protect the people using roads [6], [7].

A new concrete barrier concept is presented in this paper. The ANSYS 14 software is used to simulate the concrete barrier relationships against impact loads to verify some of the properties of concrete barriers and check the failure of the barrier system.

II. CONCRETE BARRIER MODEL

Any concrete barrier model must consider many design factors. The main factors that influence the design are width, length, and section shape. The connection of concrete barriers with one another and with the ground is also crucial. A new shape concept is presented in this paper. This design uses a new idea of concrete barriers that feature an easy construction and low-cost maintenance. The model section comprises three parts, as shown in Fig. 1.

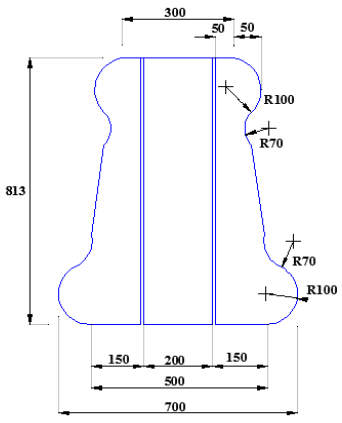


Figure 1: Section of concrete barrier

The section of the concrete barrier is curved from top to bottom to give a new architectural shape. The curve at the bottom helps reduce vehicle tire deflation, which sometimes occurs during vehicle collision with the concrete barrier. The dimensions of the proposed concrete barrier are a base width of 700 mm, a top width of 400 mm, and a height of 813 mm, which are at the limit acceptable in the roadside design criteria [5]. The weight of the concrete barrier segments is on this boundary.

III. FINITE ELEMENT MODELING OF CONCRETE BARRIER

For numerical simulation, the nonlinear explicit dynamic ANSYS 14 finite element software is used to analyze the model while applying the impact loads. A computer simulation of the impact test is conducted for the concrete barrier. Concrete strength of 30 MPa and concrete unit weight of 2,400 kg/m^3 are used.

Solid elements of tetrahedron type are used for the model meshing of the concrete barrier, and a steel rod is used as the impact load, as shown in Fig. 2. A flexible concrete model is used to show the crack and concrete failure. Impact simulation is conducted to confirm the capability of the concrete barrier model to absorb the impact load. The effect of the load in all parts of the model is also studied. In this step, a small element size can be used because a large element size cannot give good simulation results. A steel bar is used to apply load to the concrete barrier using rigid elements of structural steel. For the model meshing, the number of elements is 3138 and the number of nodes is 9094.

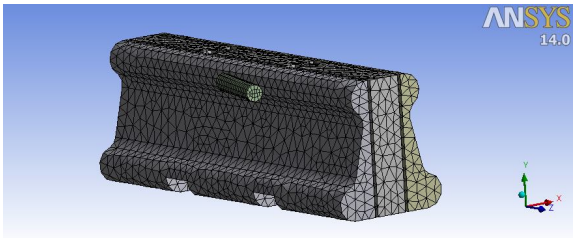
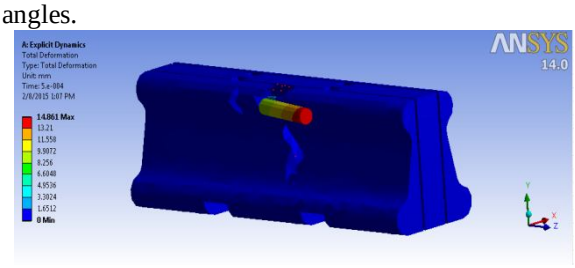


Figure 2: Meshing of the concrete barrier model

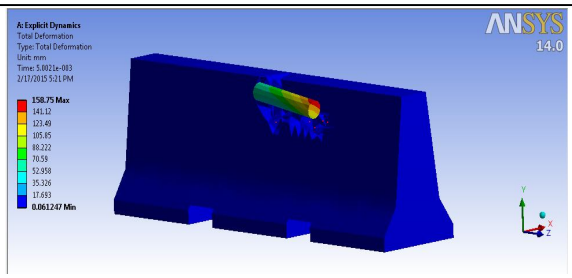
IV. RESULTS AND DISCUSSION

A. Strike Angle Effect

The failure example, as shown in Fig. 3, indicates that failure occurs only in the outer part that faces the applied load, while exist F-shape failure occurs in all barrier. The lateral deflection is 14.8 mm however, for the F-shape is 158.8 mm at the same conditions. The relationship between impact time and deformation in the outer parts is shown in Fig. 4, with different strike angles of 15°, 20°, and 25°. The use of these angles is in accordance with the Recommended Procedures for the Safety Performance Evaluation of Highway Features [3]. Deformation occurs more in the 20° than in the other two angles in the same conditions of impact load value and speed. Therefore, an applied load with 20° is more effective than that with other angles.



(a) : Failure of proposal model



(b) : Failure of exist F-shape model

Figure 3: Failure of models

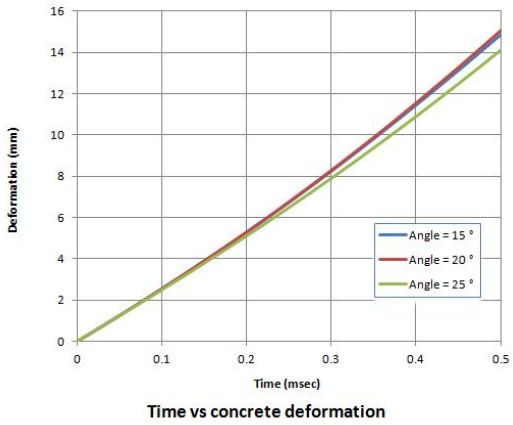


Figure 4: Relationship between the impact time and concrete deformation

Strain appears in the same tests, as shown in Fig. 5. However, the strain that occurs at 20° is larger than those at 15° and 25°. The strain of the impact force at 25° after the middle time of the impact increases more than that of the impact force at 15°.

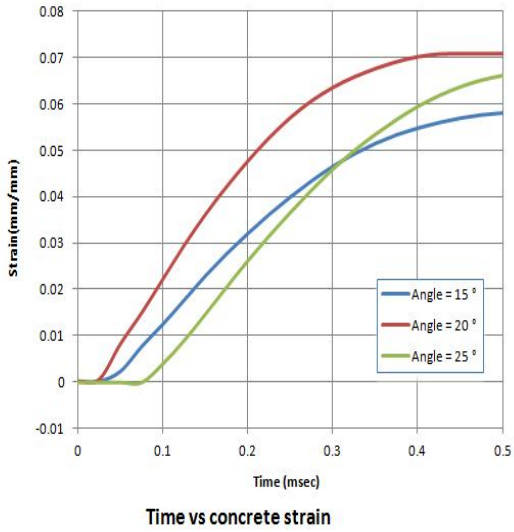


Figure 5: Relationship between the impact time and concrete strain

The stresses indicate the same behavior of strains in the same tests, as shown in Fig. 6. The stresses of 20° are larger than the stresses of 15° and 25°. The stresses that occur at 25° of the impact force increases more than those at 15° of the impact force after reaching the time of impact 0.4 ms.

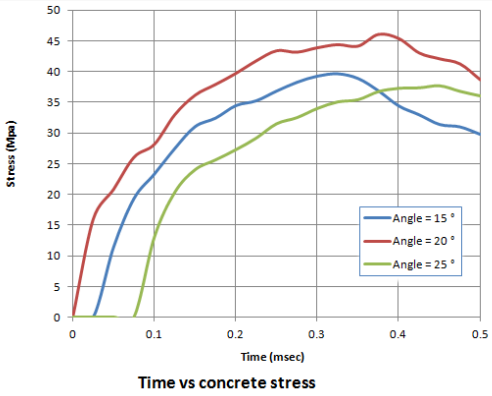


Figure 6: Relationship between the impact time and concrete stress

B. Strike Angle with Different Loads Effect

A parametric study is conducted using different impact loads at different strike angles. As shown in Table 1, the maximum lateral deflection is found from the simulation by applying loads of 0.90, 1.50, 2.0, and 10.0 tons, similar to the weight of vehicles. These loads strike the concrete barrier with 15°, 20°, and 25° collision angles. These cases aim to demonstrate the effect of different loads on different strike angles. The maximum lateral deflection increases as the impact angle decreases with the same load.

Table 1: Maximum lateral deflection of different impact loads with different collision (strike) angle

Loads (ton)	Collision (strike) angle		
	15°	20°	25°
	Maximum lateral deflection (mm)		
0.90	12.60	12.56	12.50
1.50	14.52	12.56	12.55
2.00	12.52	12.50	12.50
10.00	12.50	12.51	12.51

CONCLUSIONS

The result of the simulation analysis using finite element method indicates that crash occurs in one part that faces the impact force. By contrast, the middle part and the part opposite to the applied load are not affected. Consequently, the new concept of concrete barriers can defend against impact forces to which vehicle collision against concrete barriers applies. The concrete barrier system works with one another to prevent vehicles from transferring to the opposite lane that leads to traffic accidents. The system can also work to protect road users even if it is broken. With different strike angles against the concrete barrier, the deformations, stresses, and strains in the outer concrete part are influenced in percent by increased angles. The 20° angle is more sensitive than the other strike angles. A load of 1.5 ton provides higher maximum lateral deflection than other loads in the same condition of speed and strike angle. Future studies can focus on this load and compare it with other loads. According to roadside design specifications, the model highly agrees with the given criteria.

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