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Buffer stops behavior due to rail impact loads with LISA FEA

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ABSTRACT

The buffer stop also offers a gradual deceleration to the train, lowering the chance of passenger harm and railway damage. The buffer stop's conduct is critical for the train system's safety and integrity. The researcher conducted an analysis of the behavior of the buffer stop after being hit by an oncoming train and experienced failure in braking by using solid steel materials and with an additional layer of rubber on the head end of the train stop buffer. With reference to the impact force parameters that have been calculated in previous studies so that it can be viewed from the stress that occurs and the value of the lateral movement that occurs at the buffer stops.From the results of the analysis of this study it is known that an increase in the ability of the buffer stops by replacing steel material with rubber does not provide a significant increase, however, thickening the flange and web of the buffer stops provides a significant increase in capability with a ratio of 3,582 to the applied stress. and increased ability to reduce the length of the drift by a ratio of 2,478.

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1. INTRODUCTION

The buffer stop behavior caused by rail impact loads is to absorb the train's energy and put it to a standstill. Buffer stops are intended to keep trains from exceeding the end of the track and clashing with other items or people. When a railway collides with a buffer stop, the impact energy is released by the materials in the buffer stop compressing and deforming. The buffer stop also offers a gradual deceleration to the train, lowering the chance of passenger harm and railway damage. The buffer stop's conduct is critical for the train system's safety and integrity. Friction buffer stops are the most popular type of buffer stop due to their high resilience and diversity of configuration options. The basic strategy to building buffer stops is to use kinetic energy and convert it into labor.

In this study the researchers conducted an analysis of the behavior of the buffer stop after being hit by an oncoming train and experienced failure in braking by using solid steel materials and with an additional layer of rubber on the head end of the train stop buffer. With reference to the impact force parameters that have been calculated in previous studies so that it can be viewed from the stress that occurs and the value of the lateral movement that occurs at the buffer stops. It is hoped that this research can provide a good repertoire and contribution to the world of railways, especially in the buffer stops which are part of the important elements of the world of railways, as well as providing excellent supporting data for railway construction.

2. RESEARCH METHOD

In this study the authors will make a buffer stop model on public trains, using steel material and additional rubber influence on the front of the direct impact impact. The buffer stop modeling will use LISA FEA V.8 finite element analysis software to carry out the analysis of the buffer stop modeling with a fixed type with an overview as shown in Figure 1.

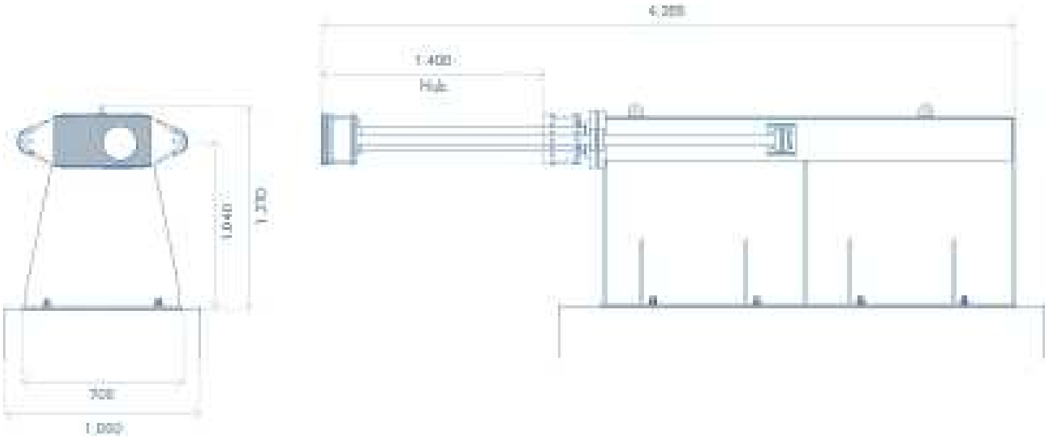

Figure 1. Typical of buffer stops with fixed type.

2.1. The Importance of Buffer Stops

A buffer stop not only marks the end of a track/closes a track, but it is also a mechanical safety device that shields commuters, other people, freight, train cars and structures, and, last but not least, the track structure itself from harm. This is significant because railway formations can have hundreds to thousands of tonnes of moving bulk. Buffer stops are widely distributed in train systems. Main lines, branch lines, metros (underground and neighborhood railways), monorails, trams, crane systems (ports), mountain railways, depots, suspended railways, and other rail vehicles are examples of these. Even with cautious tactical management or when shunting a train formation or individual vehicles, rail vehicles can crash with each other. A buffer stop, also known as a bumper, is a mechanism used to keep railway cars from continuing past the end of a physical stretch of track. Because the coupling gear is the first component of the vehicle that the buffer stop contacts, the design of the buffer stop is influenced by the type of couplings used by the railway.

Figure 2. Buffer Stops

2.2. Buffer Stops Function

Fixed buffer stops without hydraulic buffers have the same effect as a collision on a solid wall. The contact energy (kinetic energy) is returned to the striking traction unit by fixed buffer stops. Such buffer stops are typically built so that any collisions are redirected to the colliding traction unit. However, the buffer stop's construction absorbs only a tiny portion of the kinetic energy. Typically, traction unit supports are built in such a way that the energy of the rebound can be absorbed in the traction unit..

2.3. Buffer Stops Design Parameters

The kinetic energy absorbing capability of a buffer stop is an important construction component for halting a rolling stock of a certain mass with a certain collision speed. Because the position of the buffer stop can vary, the design must be approached separately. Whether the buffer stop is at the end of a dead-end track in a station by platform or at the end of a safety track (from sidings, service track, or even moving tracks). Each scenario provides us with a different pace and sort of train (its mass) that can crash into a buffer stop. As previously stated, the quantity of kinetic energy that a buffer stop can take is a critical construction parameter. Examples of kinetic energy are given in Table 1.

Table 1. Examples of kinetic energy [kJ]

Speed [km.h−1]	**Speed [m.s−1]**	**Impact mass [t]**									
		100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
10	2.78	386	773	1159	1546	1932	2319	2705	3091	3478	3864
15	4.17	869	1739	2608	3478	4347	5217	6086	6956	7825	8694

2.4. Types of Buffer Stops

As for the cross-section of the railroad track used is a railroad cross-section with a width of 1435 mm with a Several types of buffer stops that are very familiar in the world of railways are as follows:

2.4.1 Friction Buffer Stops

A friction buffer block's purpose is to safeguard the track end and its immediate environs, as well as the train vehicles themselves. If the brakes fail, the buffer stop should be intended to safely and controllably decelerate the car until it stops. If a single friction buffer stop is insufficient due to the high kinetic energy of a possible vehicle collision, extra brakes that boost the braking power in steps are required. In many instances, track reinforcement is needed due to the high braking pressures in such a scenario and to avoid track damage.

Figure 3. Friction Buffer Stops

2.3.2 Fixed Buffer Stops.

Fixed buffer stops with hydraulic absorbers can be attached to the track end in a variety of methods. (1) Including clips at the rail head. (no drilling of rail) (20 Bolting to the rail web (3) Bolting to a ready-made concrete base or platform (4) Bolting to a ready-made concrete wall. Smaller footprint area and maintenance-free dampers are advantages over friction buffer stops; disadvantages include reduced energy absorption capacity and higher cost.

Figure 4. Fixed Buffer Stops

Given its long past, the fixed (rigid) buffer stop is one of the most commonly used kinds of buffer stops. A fixed buffer stop is made up of a block or frame that is firmly attached to the tracks or the earth. Fixed buffer stops, like other structures, have advantages and disadvantages. One benefit is that it can be positioned at the end of a dead-end track, reducing the track's usable length. However, cons such as minimal resistance and deceleration mode predominate in this instance. Table 5 shows the resistances (as a condition of usefulness) of fixed buffer stops [1]. The smple fixed buffer stop's only function is to designate the end of the track; it cannot consume energy. It does not safeguard either people or vehicles.

2.4 Train Braking Performance Requirements

The braking performance of railroads is the overall performance of the braking system of locomotives (or motor cars) and cars (or trailers), and it is an assurance for safety and stopping deceleration enhancement. As a result, it serves as the foundation for increasing railway average pace. The stopping distance must be increased as the highest speed increases. The increased distance is achieved by using an electronic pneumatic and composite braking and antislip device. For example, a vehicle uses disk braking and dynamic braking, and occasionally spinning vortex braking; a trailer uses disk braking + electromagnetic rail braking or linear vortex braking. In general, as the square of the main stopping speed increases, so does the restriction of emergency braking distance. Table 2 shows the emergency stopping lengths of high-speed trains at various speeds. Normal stopping deceleration on a railway is only 50%-80% of emergency braking deceleration; thus, normal braking distance is twice that of emergency braking distance.

Table 2. Emergency Braking Distance of High-Speed Trains

V (km/h)	300	250	220	160	140
S_z **(m)**	3500	2700	1700	1400	1100

The combination of different braking settings and braking system reinforcement has resulted in a rise in both emergency braking deceleration speed and regular braking deceleration speed. Some trains' emergency stopping deceleration exceeds 1.4 m/s^2, while standard braking deceleration is 1.1 m/s^2. This is beneficial not only for safety and efficiency, but also for indicator machine placement [2]. Consider how the impact speed can be determined. The driver is accountable for braking properly in accordance with the signs. He misses a presignal by mistake and has no idea how to slow the train. That begins to decelerate using the emergency stop at the point of indication with prohibiting signal. Table 3 shows the stopping lengths (using normal and emergency brakes) and speeds of trains at the end of a dead-end track (model situation: assume 100 m between signal with prohibiting signal and buffer stop) [1].

Table 3. Deceleration of trains

Speed[km.h−1]	**Braking distance [m]**			**Speed at the end of dead-end track [km.h−1]**		
	Os	**R, Ex, IC**	**Emergency braking**	**Os**	**R, Ex, IC**	**Emergency brake**
50	192.90	214.33	40.19	35	37	*
60	277.78	308.64	57.87	48	49	*
70	378.09	420.10	78.77	60	61	*
80	493.83	548.70	102.88	71	72	13

Speed[km.h−1]	Braking distance [m]			Speed at the end of dead-end track [km.h−1]		
	Os	R, Ex, IC	Emergency braking	Os	R, Ex, IC	Emergency brake
90	625.00	694.44	130.21	82	83	43
100	771	857.34	160.75	93	94	61

As a mechanism (structure) that has to cease buffering, work correctly while maintaining a high degree of safety and dependability, we must include a safety coefficient. in computations. As a result, the kinetics of the buffer halt The energy absorption capability must be calculated as follows:

$$R >= E_{kin,c}k \quad (1)$$

R= buffer stop's kinetic energy absorbing capacity [J]
$E_{kin,c}$= total kinetic energy [j]
K= safety coefficient [-]

In Table 4 are shown examples of safety coefficient graded by the level of protection and type of train according to Austrian standards [3].

Table 4. Safety coefficient

Type of train and security level	k [-]
Passengers trains	1.5
Freight trains and shunting	1.2
Freight trains and shunting, when it is necessary toprotect various systems which are located behand or nearby buffer stop	1.5
Freight trains and shunting, in cases where there aretraffic zones, structures or residential houses located behind or nearby buffer stop	1.8
Preventing the fall of any train or rolling stock into abyss	2.0

2.5 Finite element method (FEM)

The finite element method (FEM) is a mathematical strategy used to deal with specific evaluation problems. The limited component approach combines a few numerical concepts to generate straight or nonlinear framework conditions. The number of conditions produced is usually extremely large, exceeding 20,000 conditions. As a result, unless a decent PC is used, this approach is of little practical value. When a design is subjected to forces such as stress, pressure, temperature, stream rate, and severity, the result is strain (distortion), stress, temperature, tension, and stream rate. The concept of the following action (twisting) on a body is based on the characteristics of the power and stress structure itself. The dissemination of this effect, conveyed as dislodging, can be tracked down in the limited component approach.To deal with the problem of tracking down relocations of vertices/associations/grids and primary powers, the finite element technique employs a component discretization method [9] [15] [23]. Discrete component conditions are linked with the lattice method for initial examination, and the results obtained are indistinguishable from those obtained from conventional structural inquiry. Discreteness should be achievable using one-layered components (line components), two-layered components (planar components), or three-layered components (volume/continuum components). This method employs a continuous component to determine a more accurate response [4]–[13].

2.5 LISA FEA V.8

LISA FEA V.8, The temperature rise for three different types of intensity exchangers was measured using a well-known restricted component examination program. The three types of models are, in order of their simplicity and ease of creation, the line component model, the shell model, and the robust model. LISA provides a selection of commonly used underlying forms for line components; customers simply put the component's aspects in a single exchange box and warm conductivity in another dialogue box. Because research cannot prevent convection from gathering the baseplate surface with the face determination device, the convection coefficient of the baseplate surface is not fixed in stone as a part of the worth employed somewhere else for line component models only. It's merely a matter of mental alertness [10]. For the other two versions, it's simple to prevent flow from the mounting surface - we simply don't use it. For each scenario, an interior intensity generator is used, and the volume of the entire floor component is considered to be the intensity source. When adding limit conditions to a line component model, exercise caution. [14]–[22].

3. RESULTS AND DISCUSSION

In this study the researchers compared the stresses that occur in the buffer stop construction on railroads that will be impacted by a load of 1000000 N with the kinetic energy equation of around 869,000.00 Nmm where the speed of the train at the time of impact is 15 km/h, from the results of this impact load it will produce stresses and lateral deformations in the buffer stop and will notice the change in behavior that occurs when the buffer stop head is changed to a rubber material. The load used is a load of 100 tons or 1000,000 N with a web profile thickness of 8 mm and a flange of 12 mm, while for the stop buffer the thickness of the head buffer is 40 mm and the head buffer wall is 20 mm while the material used in the modeling is as following [15] [16].

Table 5. Material Properties

Material	**Young Modulus (N/mm2)**	**Density (N/mm3)**	**Poison Rasio**
Steel	210000	0.0000785	0.3
Rubber	500000	0.0000120	0.5

As for the modeling carried out, it can be seen in Figure 1 below that it adjusts one of the fixid type block stops.

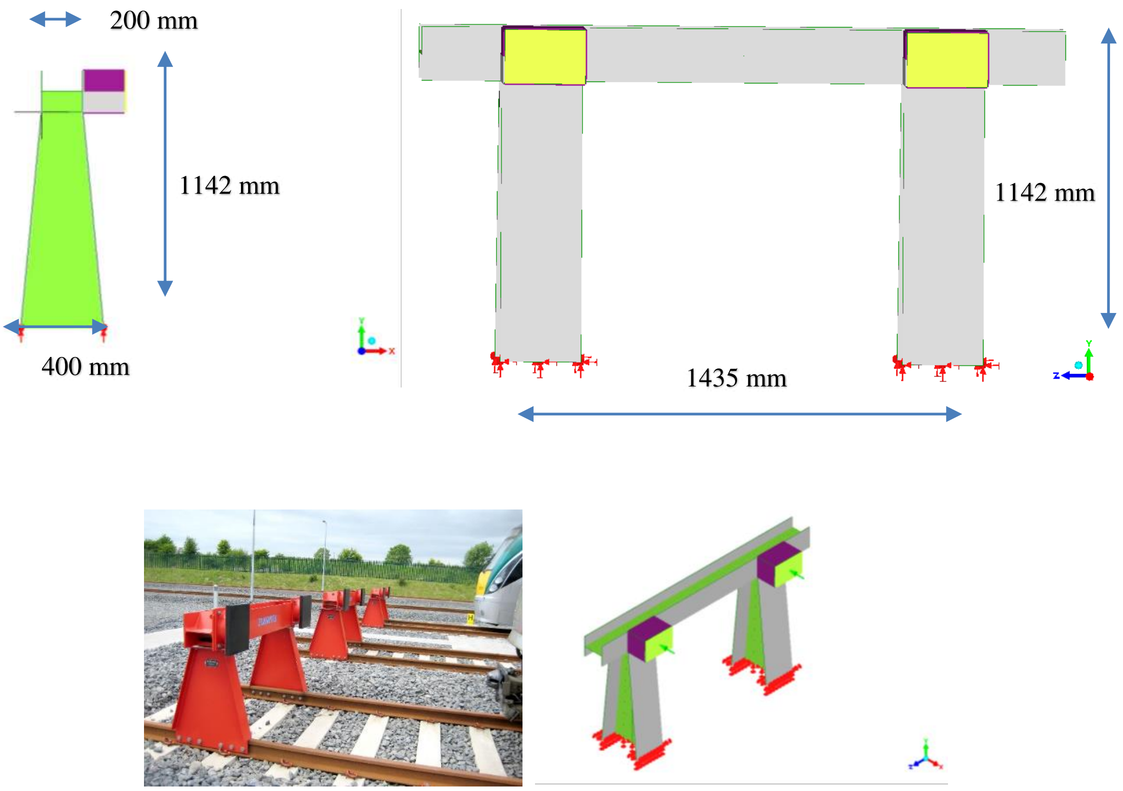

Figure 5. Modeling of fixed buffer stops

3.1. Stress Behavior of Steel Buffer Stops Head

The first model uses a buffer stops head with steel plate material with a thickness of 40 mm and is given an impact load as shown in table 1 where the train moves at a speed of 15 km/h and the impact load is 100 tons = 1,000,000 N. The maximum stress that occurs is obtained is 510.7 N/mm^2 and the stress value at the point of impact load is 5.969 N/mm^2. It is shown in Figure 6 where the maximum stress occurs concentrating on the impact area of the load seen at the junction of the buffer stops head with the feet of the buffer stops shown in Figure 7 which is equal to 509.28 N/mm^2. The allowable stress for type BJ 37 steel is 160 N/mm^2 with a yield stress limit of 240 N/mm^2, so in this condition the stop buffer foot area fails because the stress that occurs exceeds the allowable stress of the steel material. However, in the head area, the stop buffer has a stress value below 160 N/mm^2.

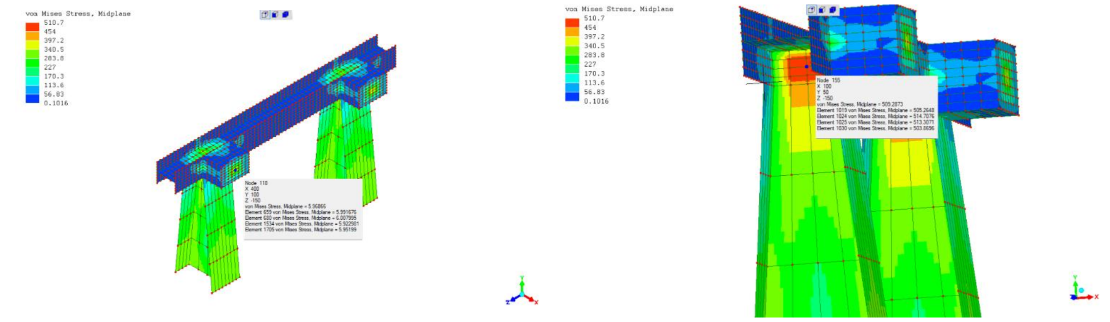

Figure 6. (a) Stress that occurs at the point of impact load (b) The maximum stress hue that occurs

As a result of the impact load that occurs, the buffer stop element experiences lateral movement (drift), where the drift value that occurs is 8.797 mm, as shown in Figure 8.

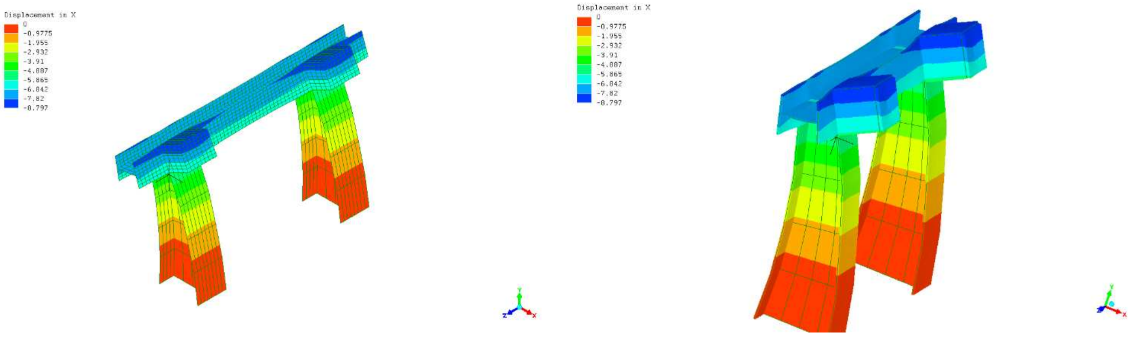

Figure 7. Drifts that occur at buffer stops

3.2. Stress behavior after additional thickness of steel Buffer stops head

The second model uses a buffer stops head with a rubber material thickness of 40 mm and is given an impact load as shown in table 1 where the train moves at a speed of 15 km/h and the impact load is 100 tons = 1,000,000 N. The maximum stress that occurs is 509.7 N/mm^2 and the stress value at the point of impact load is 4.56 N/mm^2. It is shown in Figure 8 where the maximum stress occurs concentrating on the impact area of the load seen at the junction of the buffer stops head with the buffer stops feet shown in Figure 10 which is equal to 508.29 N/mm^2. The allowable stress of this BJ 37 type steel is 160 N/mm2 with a yield stress limit of 240 N/mm2, so in this condition the stop buffer foot area fails because the stress that occurs exceeds the allowable stress of the steel material. However, in the head area, the stop buffer has a stress value below 160 N/mm2.

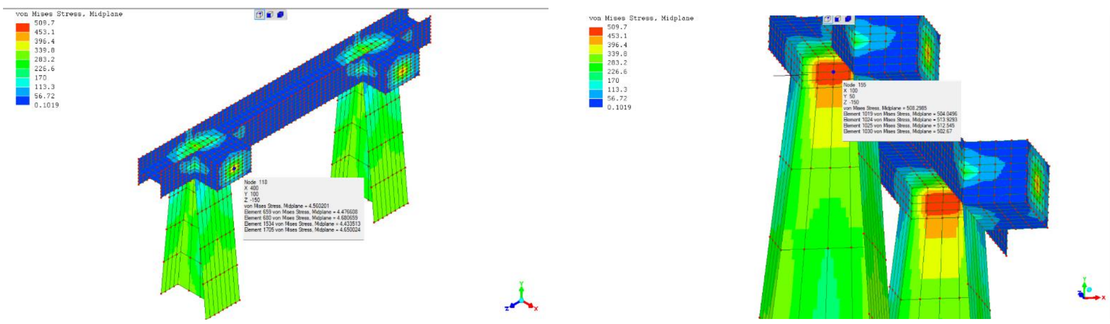

Figure 8. (a) Stress that occurs at the point of impact load (b) The maximum stress hue that occurs

As a result of the impact load that occurs, the buffer stop element experiences lateral movement (drift), where the drift value that occurs is 8.775 mm, as shown in Figure 9.

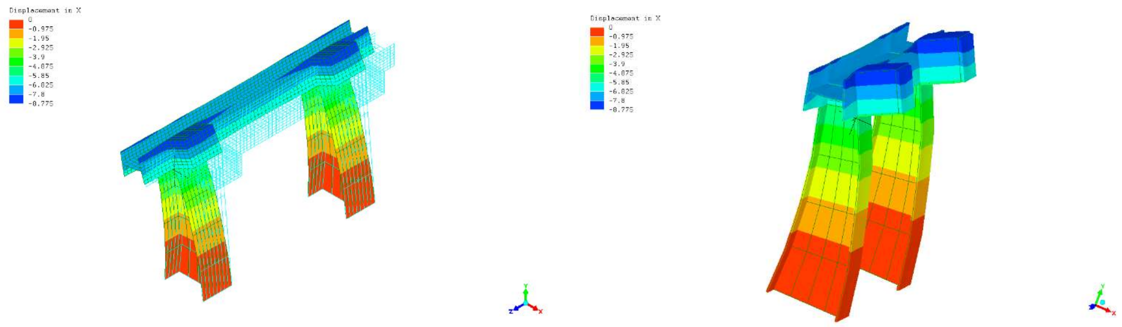

Figure 9. Drifts that occur at buffer stops

3.3 Stress behavior after additional thickness of steel Buffer stops head

The third model adds thickness to the web part of the buffer stop foot by 20 mm and the thickness of the flange is increased to 25 mm by using a buffer stop head with steel material with a thickness of 40 mm and given an impact load as shown in table 1 where the train moves at a speed of 15 km /h and the impact load is 100 tons = 1,000,000 N. The maximum stress value that occurs is 408.2 N/mm2 and the stress value at the impact load point is 5.11 N/mm2. It is shown in Figure 6 where the maximum stress occurs concentrating on the load impact area can be seen at the junction of the buffer stops head with the buffer stops shown in Figure 7 which is equal to 142.18 N/mm^2. The allowable stress of type BJ 37 steel is 160 N/mm2 with a yield stress limit of 240 N/mm2, so in this condition the buffer foot area stop fails because the stress that occurs exceeds the allowable stress of the steel material. However, in the head area, the stop buffer has a stress value below 160 N/mm2.

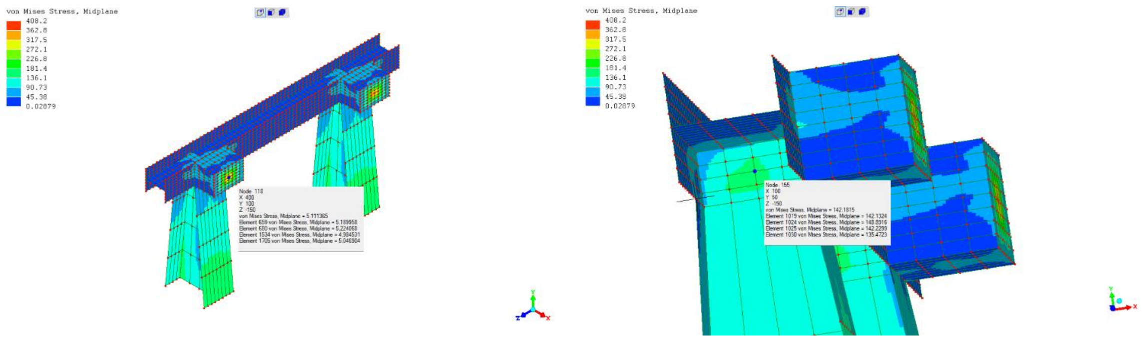

Figure 10. (a) Stress that occurs at the point of impact load (b) The maximum stress hue that occurs

As a result of the impact load that occurs, the buffer stop element experiences lateral movement (drift), where the drift value that occurs is 3.55 mm, as shown in Figure 11.

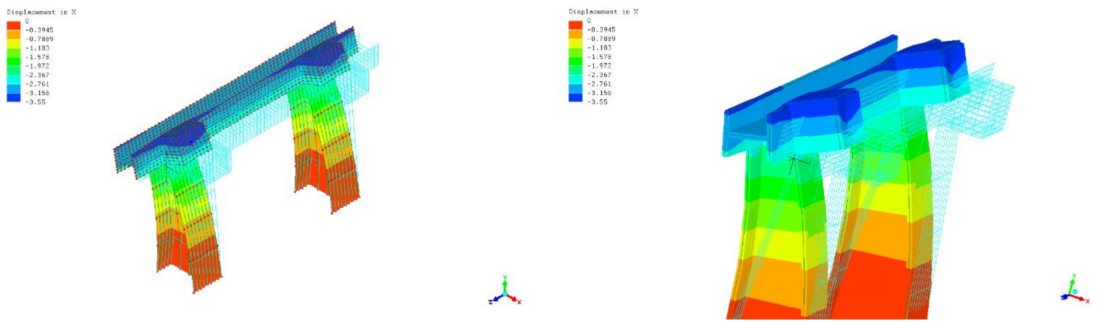

Figure 11. Drifts that occur at buffer stops

4. CONCLUSION

From the results of the analysis of this study it is known that an increase in the ability of the buffer stops by replacing steel material with rubber does not provide a significant increase, however, thickening the flange and web of the buffer stops provides a significant increase in capability with a ratio of 3,582 to the applied stress. and increased ability to reduce the length of the drift by a ratio of 2,478. This research needs to be continued by conducting experimental tests to provide information and validate the results of numerical tests, especially regarding loading options, the type of buffer stop head material, the buffer stops foot system and several very broad options to be re-examined.

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