



Investigation on Structural Response of New Zealand Light Steel Frame and its Equivalent Truss Frame under Lateral Loading

Rasheddin Cheraghi¹, Hamidreza Mohammadzadeh²

Abstract

A very popular type of light steel frames is New Zealand Light Steel Frame (NZ LSF) which is produced by CAD/CAM technology. All structural elements of this frame including studs, braces and bridges have the same channel cross section and connect together by self-drilling screws. All structural connections in NZ LSF are hinged. This issue leads the mind to the point that the frame may be equivalent to a truss frame. However, an important distinction exists between the NZ LSF with a truss frame and that is the eccentricity of braces in joints. In this research, a numerical analysis is conducted to compare the response of an exact NZ LSF vs. its equivalent truss frame (ETF) under lateral loading. The results demonstrate that generally maximum axial forces in studs and braces in the ETF model are evaluated less in comparison to the exact model but the maximum axial forces in bridges are evaluated almost the same in comparison to the exact model. Furthermore, the considerable shear forces in bridges are neglected in the ETF model. The simplified model is very close in its response to exact model. Nevertheless, the braces' eccentricity imposes considerable shear forces and bending moments in bridges.

1. Introduction

A very common type of light steel frames is New Zealand light steel frame (NZ LSF) and it has become widespread in IRAN, too. The popularity of this frame is for following reasons:

- 1- Computer software is used both in design and manufacturing of this frame. Therefore, a LSF building designed and modeled by the computer, go to the product line to precisely manufacture that building. This procedure is known as Computer-aided Design and Computer-aided Manufacturing, CAD/CAM. This procedure elevates the speed and accuracy of construction.
- 2- This frame does not need any extra connection's pieces in comparison to light steel frame which are more popular in North America and all elements connect together with self-drilling screws. Although this issue highly accelerates the process of construction, it makes some limitations on the design of high-rise buildings with the NZ LSF.
- 3- Reaching a rigid frame is easy in this frame without any need to attach a few of claddings.

¹PhD Candidate, Khajeh Nasir Toosi University of Technology, <rashidcheraghi@email.kntu.ac.ir>

¹Technical Office Manager, Panah Saz Alvand Engineering Company

² PhD Candidate, Islamic Azad University, South Tehran Branch, <mohammadzadeh@atpeco.ir>

² CEO, Aria Tadbir Paj Engineering Company

We mentioned this frame as the New Zealand Light Steel Frame, because this frame for the building of low-rise residential structures is popular in New Zealand. Moreover, there is a standard for this type of light steel frame by that country (Nash Standard 2010). A New Zealand Light Steel Frame was demonstrated in the Fig. 1.



Figure 1: A New Zealand Light Steel Frame (V.P. Paton-Cole 2010)

The response of NZ LSF under gravity and wind loads was more under investigation by researchers, but the seismic response of this frame was not under attention as much. On the other hand, we saw that for easy modeling, many designers ignore the braces' eccentricity in their numerical modeling. Therefore, in this research, an exact NZ LSF was selected and its response was compared with its equivalent truss frame (ETF) under the seismic load to demonstrate that what are the pros and cons of simplifying the exact model as the ETF model.

2. Case Studies

2.1 Material and Cross Section

The Material used in this research are mentioned in the table 1 and the cross section of elements including studs, bridges and braces is all the C-shape profile with following geometrical characteristics as drawn in Fig. 2.

ST230	F_y (Mpa)	F_u (Mpa)	E (Gpa)
	230	310	200

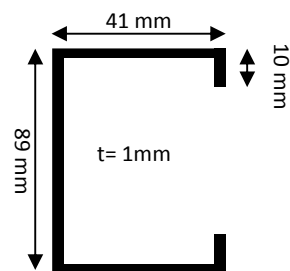


Figure 2: C-shape Cross Section

2.3 Numerical Simulation

It is tried to model the connections of NZ LSF precisely. In Fig. 5, the details of brace to bridge, bridge to stud and stud to track connection are illustrated. It is worthwhile to mention that at the connection of bridge to stud, the bridge is unable to resist moment, but at the connection of track to stud, the track is able to resist moment and its behavior is like a multi-support continuous beam. This issue is spotlighted in the fig. 5.

Be concerned with aforementioned points, the numerical model was developed in the Fig. 6. The numerical model of equivalent truss frame was built exactly like NZ LSF except for ignoring the braces' eccentricity and it is shown in the Fig. 7.



Figure 5: The Connection of Bridge to Stud (Left) and The Connection of Stud to upper Track (Right)

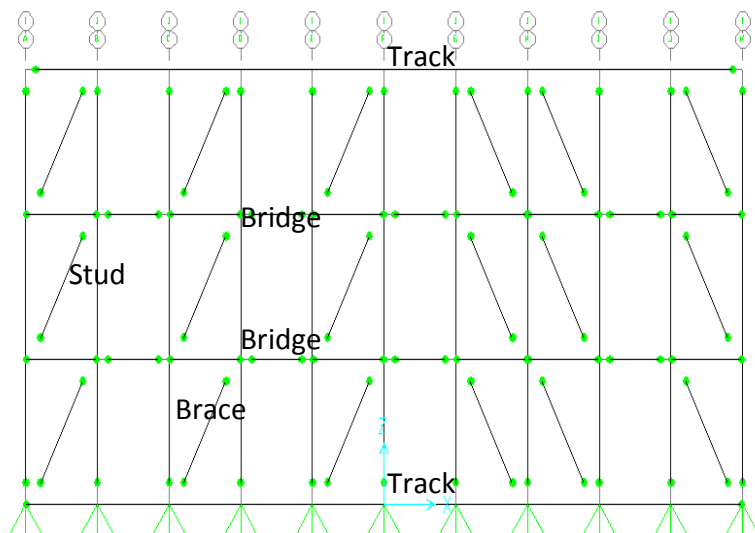


Figure 6: Exact Numerical Model of NZ LSF

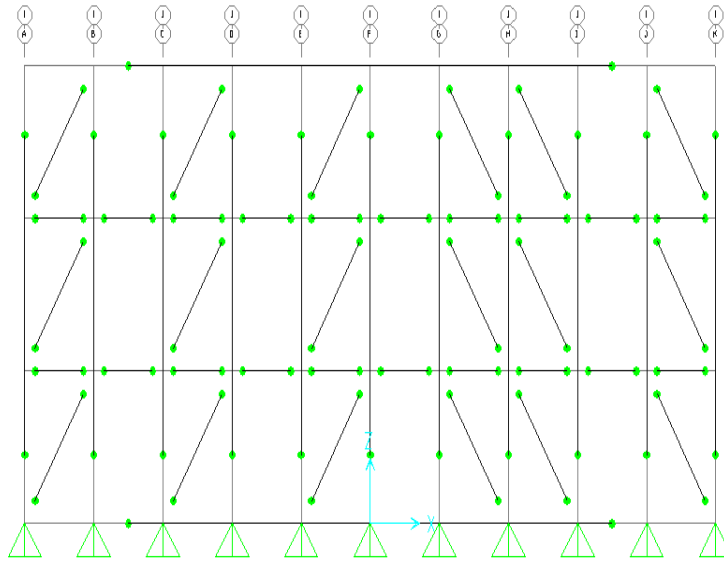


Figure 7: Equivalent Truss Frame Model of NZ LSF

3. Results

The frames were analyzed in the finite element software, SAP2000 ver14 and the internal forces including axial and shear forces and the bending moment under the 1200 kg_f seismic load were calculated in both Exact and the ETF model. All forces and moments mentioned in the following figures are in the units of kg_f and kg_f.m.

As illustrated in Fig. 8 and Fig. 9, the maximum tension and compression forces in studs in the exact model are 1183 kg_f and 945 kg_f, respectively and in the ETF model are 1074 and 835 kg_f, respectively. Furthermore, the maximum tension and compression forces in Braces in the exact model are 435 kg_f and 610 kg_f, respectively and in the ETF model are 378 and 677 kg_f, respectively. And at the end, the maximum tension and compression forces in Bridges in the exact model are 245 kg_f and 187 kg_f, respectively and in the ETF model are 235 and 210 kg_f, respectively.

In both frames, the distribution of axial forces is similar and close together, but generally, in the ETF model axial forces in studs and braces are evaluated less in comparison to the exact model and axial forces in bridges in both models are almost the same.

As depicted in Fig. 10 and Fig. 11, the considerable shear forces and bending moments are imposed to the bridges under the seismic load. And this is the main distinction between the exact model and the ETF model. As shown in the Fig. 12 and Fig. 13, In the ETF model, the shear forces and bending moments are only observed in the upper track and their values are not considerable. Moreover, in the exact model, the maximum shear force and the maximum bending moment in bridges are 485 kg_f and 22 kg_f.m and in the ETF model, are 30 kg_f and 10 kg_f.m .

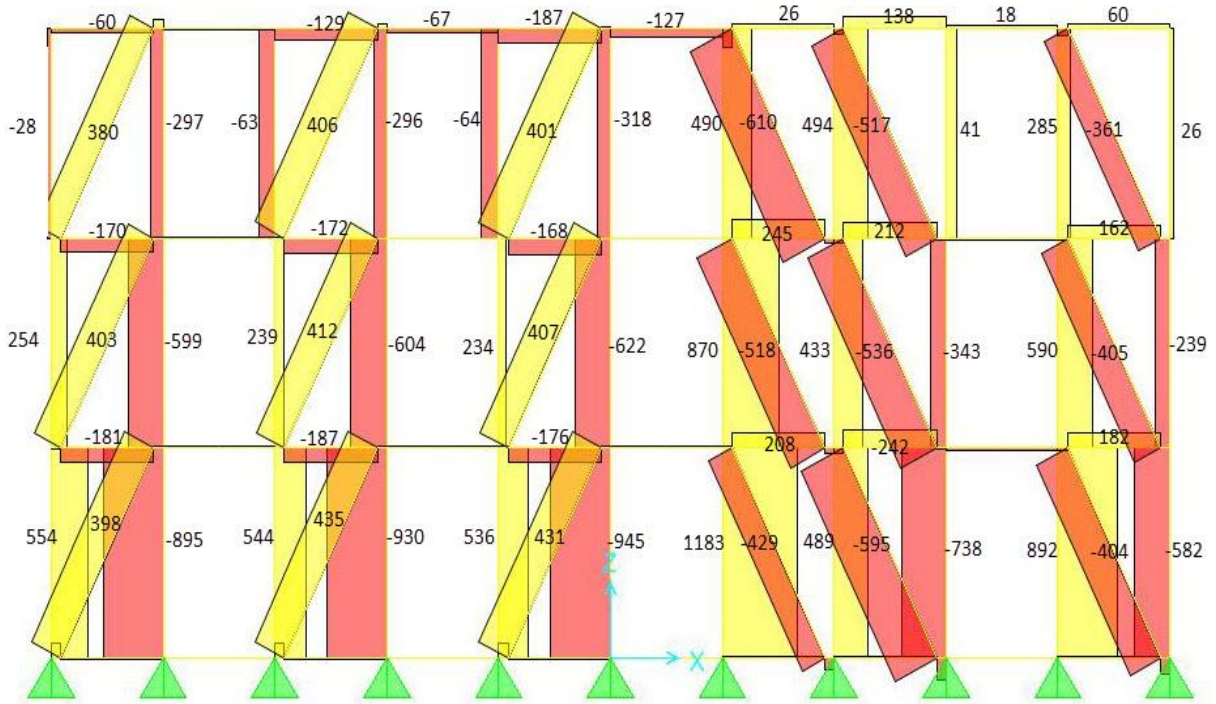


Figure 8: Axial Forces of the Exact Model

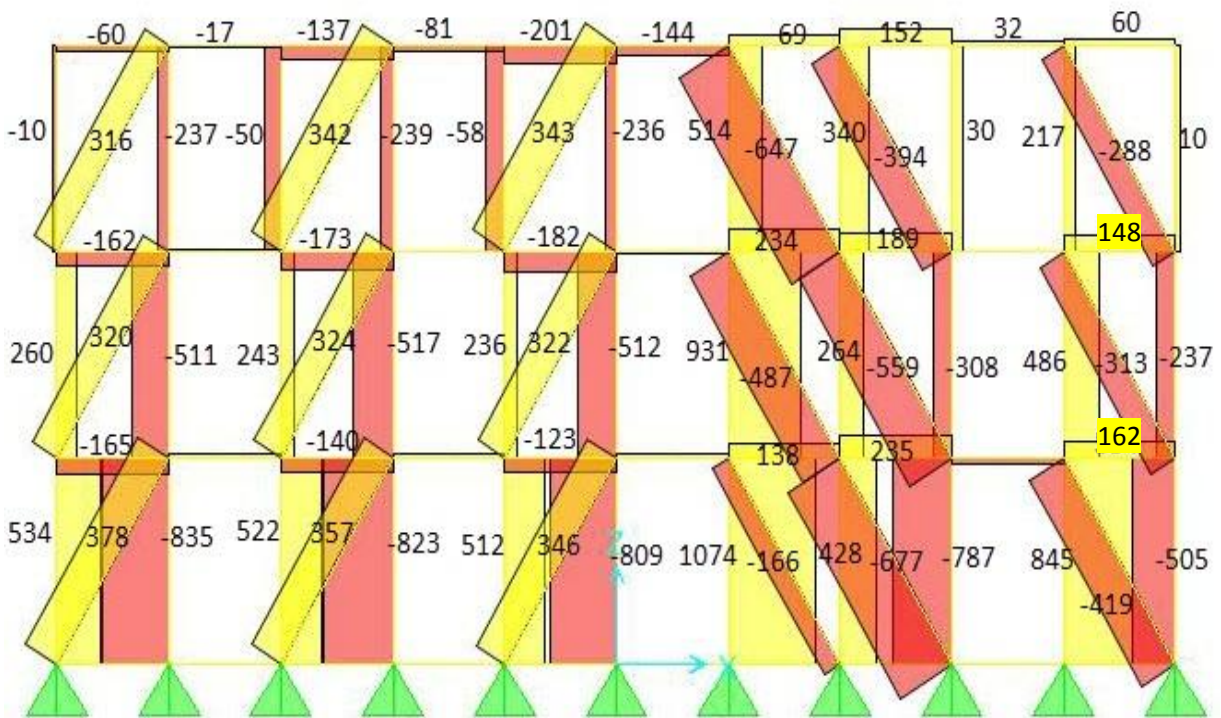


Figure 9: Axial Forces of the ETF Model

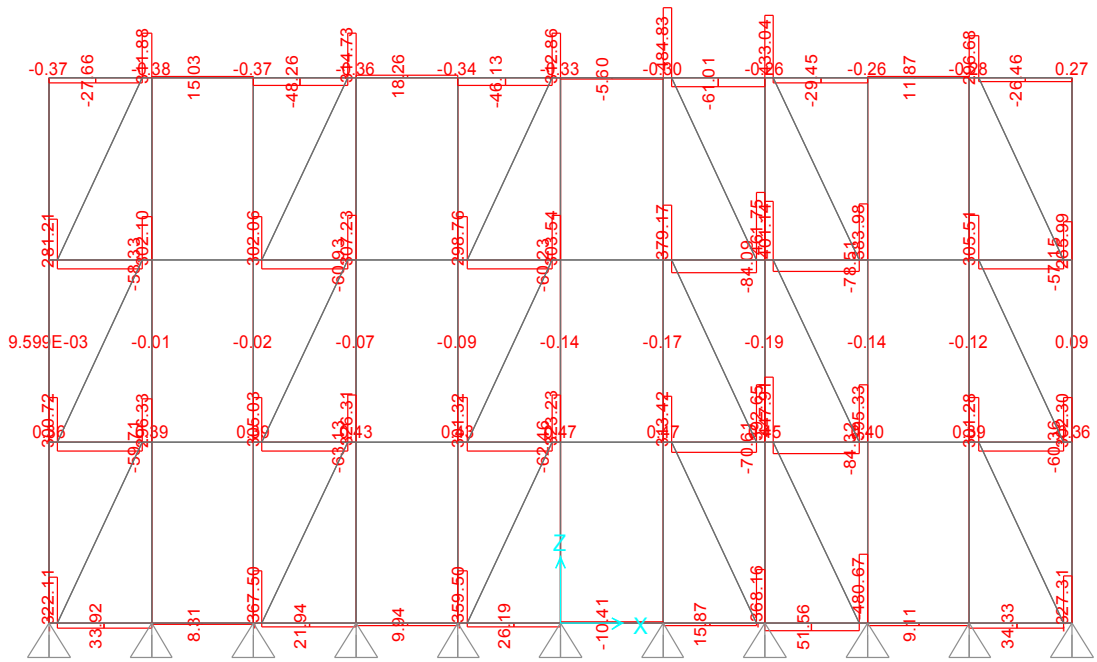


Figure 10: Shear Force Diagram of the exact model

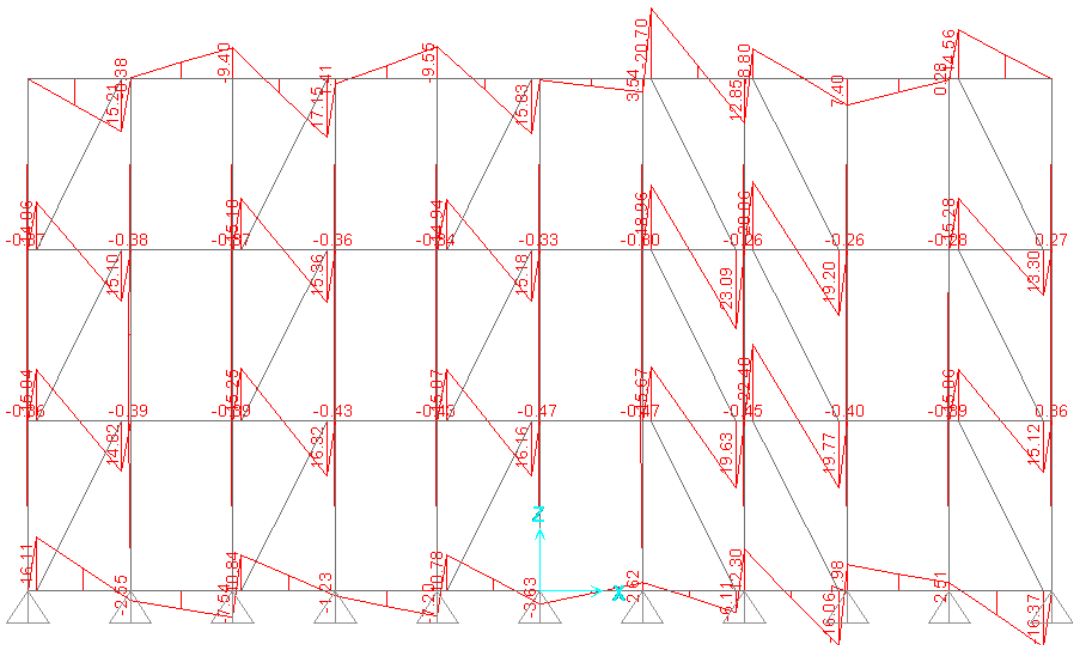


Figure 11: Bending Moment Diagram of the exact model

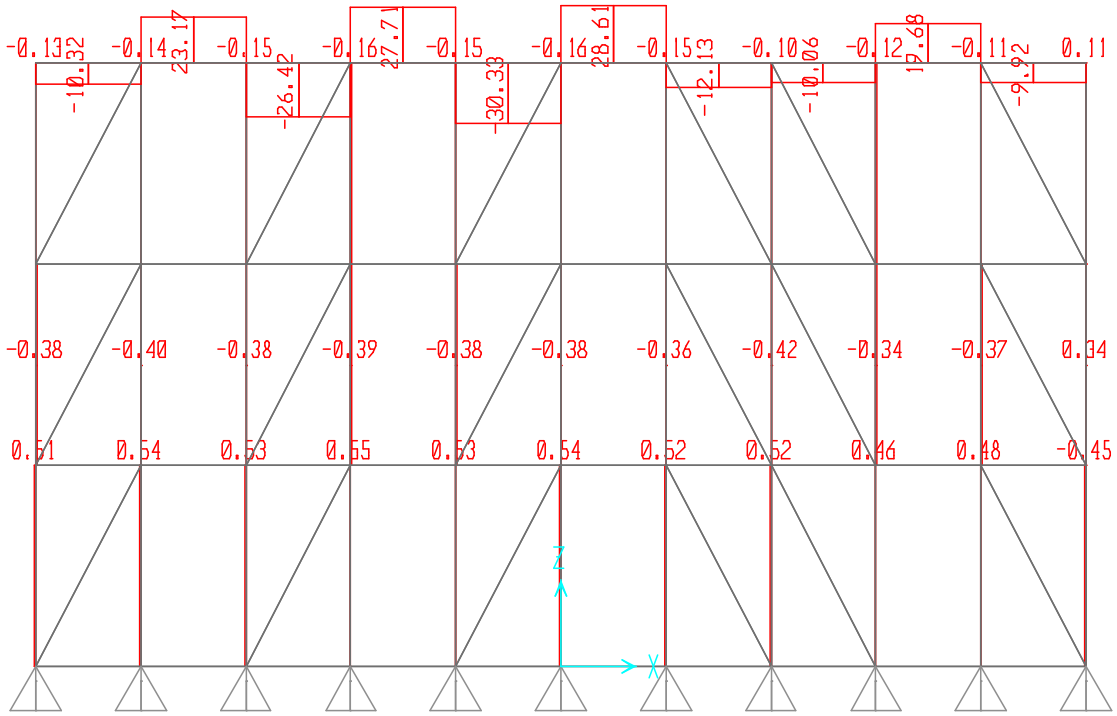


Figure 12: Shear Force Diagram of the ETF model

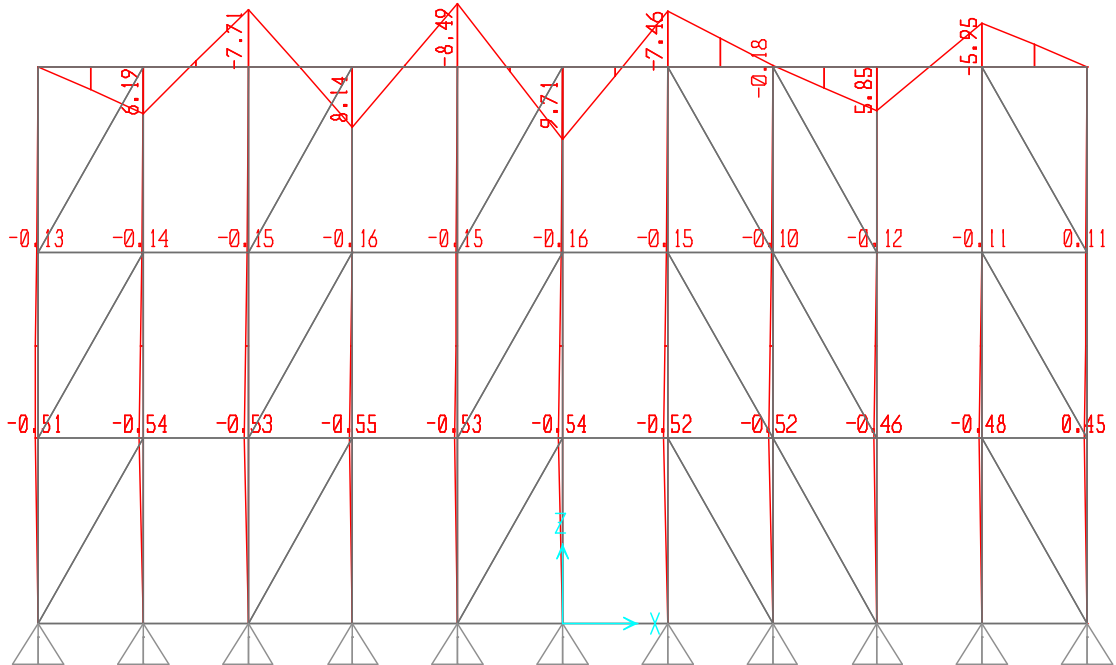


Figure 13: Bending Moment Diagram of the ETF model

4. Conclusion

The response of New Zealand light steel frame and its equivalent truss frame under lateral loading were investigated. All internal forces were calculated in both frames and compared together and following conclusions were obtained:

- In the ETF model, the axial forces in studs and braces were computed less in comparison to the exact model and this reduction is about 10%-12% for maximum forces in studs and is about 13% for the maximum tension force in braces. However, there are some exceptions that axial forces were evaluated more in comparison to the exact model.
- As the 5 cm braces' eccentricities were eliminated in the ETF model, the considerable shear forces and bending moments existing in bridges in the exact model, were neglected. To other words, the maximum shear force in the exact model is 485 kg_f which is a noticeable force in comparison to the maximum 30 kg_f shear force in the ETF model which bridges should resist. Therefore, the ETF model will highly underestimate shear forces and bending moments in the bridges under the seismic load and moreover the distribution of these internal forces through the frame are completely different from the exact model.

References

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