

Geotechnical/ Structures

MAY 2026**Project Title:** Shake Table Tests of
Grade 80 Piers**Task Number:** 4027**Start Date:** April 18, 2024**Completion Date:** December 31, 2026**Task Manager:**

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Shake Table Tests of Grade 80 Piers

Assessing Dynamic Response of Bridges Constructed
with High Strength Steel using Shake Table Testing and
Dynamic Modelling

WHAT IS THE NEED?

American Society for Testing and Materials (ASTM) A706 Grade 80 is a type of reinforcing steel, or rebar, that is much stronger than the Grade 60 steel commonly used in bridges. State transportation agencies in the United States have not widely approved Grade 80 rebar for bridge construction.

The Department of Transportation in the states of Oregon, Washington, and Alaska have studied the use of Grade 80 rebar. In these states, Grade 80 can be used in certain parts of bridges where the design requires the member to remain strong (e.g., girders, cap beams) and where there is a need to reduce the rebar congestion. Some large rebar suppliers estimate that 10–15% of the steel they sell is Grade 80 rebar used in some building construction.

Using stronger rebar may provide several benefits. It can reduce the amount of steel needed in a structure. It can also reduce crowding between the steel bars, making it easier for workers to place and properly compact the concrete. In some cases, it may allow the use of smaller bars, reduce construction time and cost, and lower the environmental impact of construction.

The 8th edition of the American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications allows the use of ASTM A706 Grade 80 rebar. Several universities, including the University of California, San Diego, and North Carolina State University, have also studied this type of steel. Their research has looked at its strength, ability to bend without breaking, and performance during earthquakes.

However, bridge columns constructed with Grade 80 rebar have not yet been tested during rapidly varying and reversing ground motion, such as an earthquake. Researchers expect it to perform similarly to what has been seen in laboratory tests where such columns were tested under controlled cyclic loads. However, there is still some uncertainty about the

capacity deterioration of such bridge columns by forces applied in quick successions.

In particular, rapid loading could affect areas of high stress that form around the ribs, or raised patterns, on the surface of the rebar. These areas could affect how much the steel can bend before it fails. More testing is needed to better understand how Grade 80 rebar will perform in bridges during earthquakes.

WHAT ARE WE DOING?

To determine whether Grade 80 steel can be safely used in all components of bridges including columns, we need to study how the bridge columns with Grade 80 rebars behave during an earthquake.

Our work includes three main tasks:

- **Earthquake testing:** We will use machine controlled platform called a shake table to move bridge columns in ways that are similar to the movement caused by real earthquakes. We will test columns made with both types of Grade 80 steel that are currently available: micro-alloyed (MA) steel and quench-self-tempered (QST) steel.
- **Computer modeling:** We will use computer models to study how the bridge columns respond to earthquake forces. These models will help us understand what happens when the columns bend, move, or experience other changes such as cracking, spalling during an earthquake.
- **Check existing recommendations:** We will compare the results of these earthquake loading tests with recommendations developed from earlier cyclic tests. This will help determine whether those recommendations can be used by the California Department of Transportation (Caltrans) when designing bridges with Grade 80 steel.

WHAT IS OUR GOAL?

The goal of this research is to develop recommendations for using Grade 80 reinforcing steel to design bridges that can withstand earthquakes.

WHAT IS THE BENEFIT?

Using stronger Grade 80 steel in bridges could reduce the amount of steel needed. Because the steel is stronger, fewer bars would be needed to provide the same amount of strength in parts of the bridge, such as the cap beam.

Using fewer steel bars can also reduce congestion of rebars in the bridge components including joints. This can make it easier to place and properly compact the concrete, especially where bridge columns connect to the foundation or cap beam.

Grade 80 steel hoops and ties can also provide stronger support around the main steel bars in a bridge column or beam. This support can help keep the main rebars from buckling, or bending out of shape, when these bridge components are subjected to reversible loads from earthquakes.

WHAT IS THE PROGRESS TO DATE?

So far, the research team has tested specimen CA4, which is a bridge column made with Grade 60 steel. The column had 12 #5 steel bars running vertically through it. This column is being used as a comparison to columns made with stronger Grade 80 steel.

The team has also started building specimens CA5 and CA6. These columns will each use 8 #5 steel bars. Using fewer steel bars will allow the researchers to study how changing the amount of steel affects the performance of the columns. The results will also be compared with Grade 60 columns tested in another shake-table project at North Carolina State University (NCSU).

Specimens CA2, CA3, and CA4 are designed as a comparison group. CA2 and CA3 have the same basic design and use Grade 80 steel, but the steel

was made using two different manufacturing methods. CA4 uses Grade 60 steel and was designed to have similar strength to the Grade 80 columns. This allows the researchers to make a direct comparison between the different types of steel.

All three columns were tested using the same pattern of ground motions simulating an earthquake shown in Figure 2.

Figure 1 shows how the changes in specimen CA4 at various damage levels.

Figure 2 shows how far the column moved during the test.

IMAGE

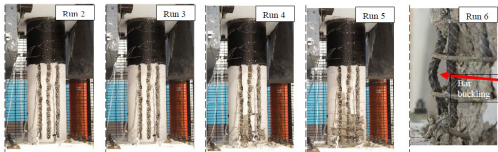


Image 1: Changes in specimen CA4 at various damage levels

Summary Set					
#	Base record	Scale	CA2 (MA)	CA3 (QST)	CA4 (G60)
			Δ_{max} (mm)	Δ_{max} (mm)	Δ_{max} (mm)
1	Tabas	0.5	5	6	5
2	Tabas	0.5	31	30	24
3	Tabas	1	48	48	39
4	Loma Prieta	3.5	124	131	118
5	Loma Prieta	-4.2	133	123	121
6	Loma Prieta	-4.2	167	122	157

Image 2: Summary of Column Displacement Set