SEISMIC DUCTILITY DEVICE (SDD) COMMERCIAL COMPONENT

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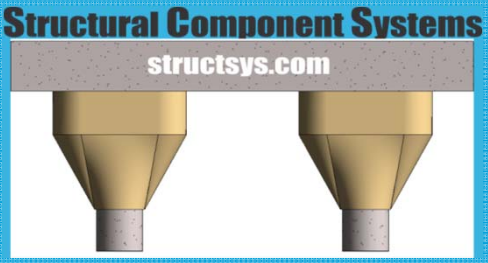
2015

Delivery of Accelerated Bridge Construction
A WSDOT Workshop



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Steve Fitz
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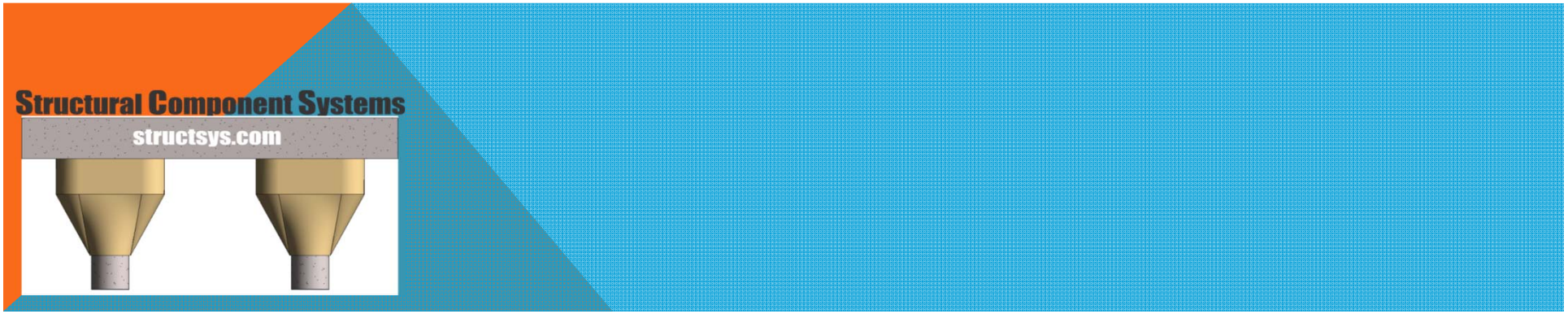
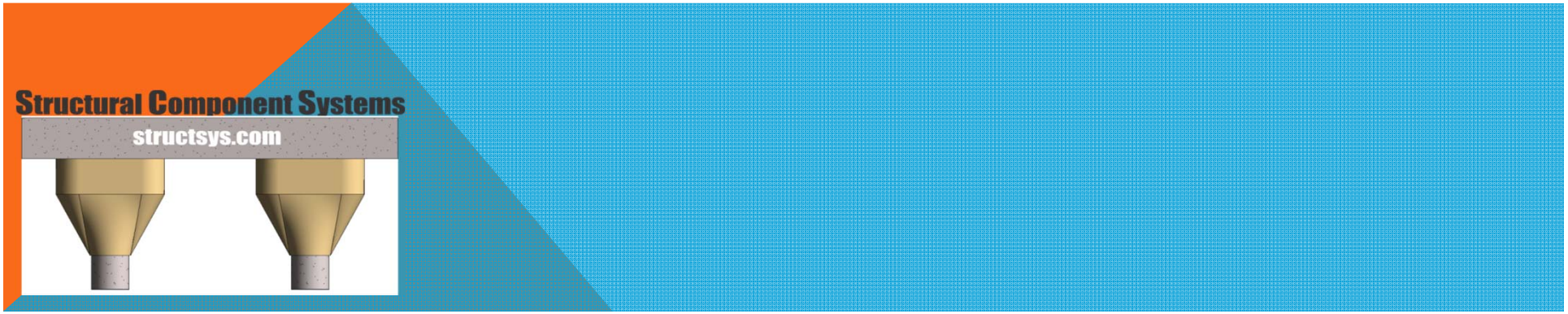
WHAT IS A SEISMIC DUCTILITY DEVICE?

- **A SDD is a structural element designed to:**
  - Provide the ductility necessary to prevent collapse through:
    - Release of elastic energy through hysteresis
    - Self centering due to super-elastic material
  - Protect other elements of the structure from overload
    - Lower stiffness – moves bridge fundamental period.
  - Provide for modular repair of the device or portions of the device designed to accept damage.
  - Integrate with Accelerated Bridge Construction (ABC) methodologies and techniques to allow modular construction of ductile precast concrete columns.

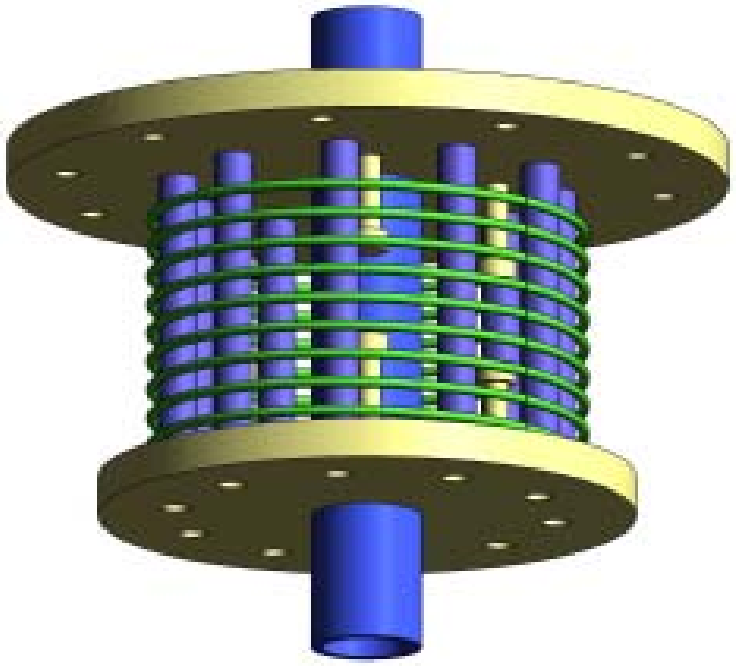


PRINCIPLES OF THE SCS SDD

- **Take the forces developed by earthquake loads and use specific materials/techniques to transmit them.**
- **Each force path has specific characteristics to either carry the force or modify it by deforming as needed.**
  - Compression: force can be directly transmitted by concrete.
    - The goal is to minimize crushing and insure that any crushing is very limited to minimize possible catastrophic failure.
  - Shear: Transmit the shear without interaction in tension or compression that may combine to increase damage.
  - Tension: use tension connections that can absorb energy by stretching without permanent damage.

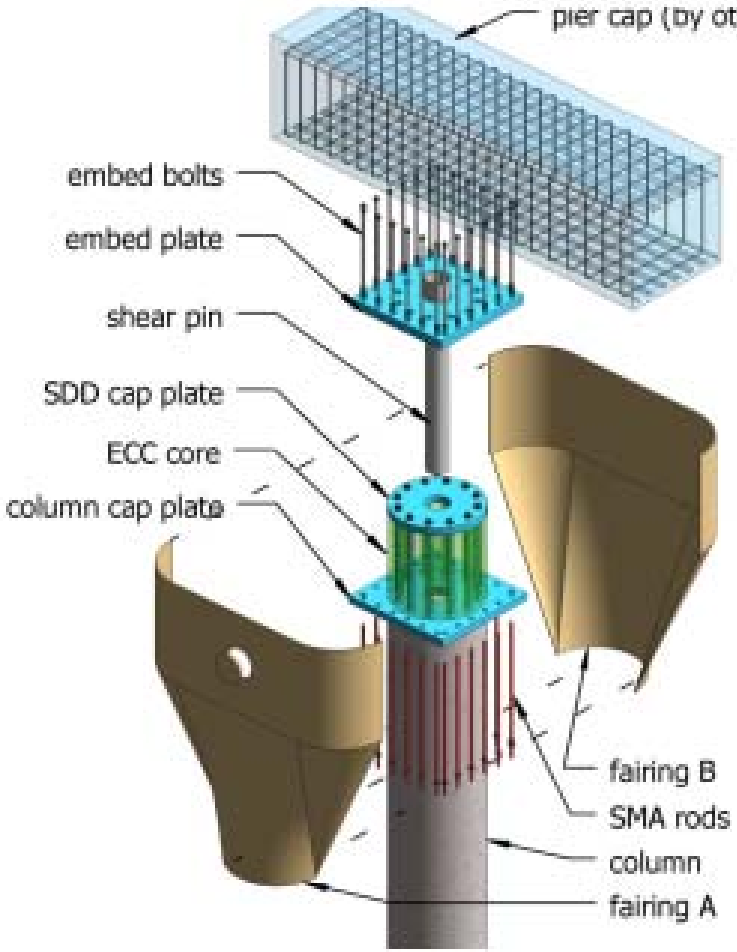


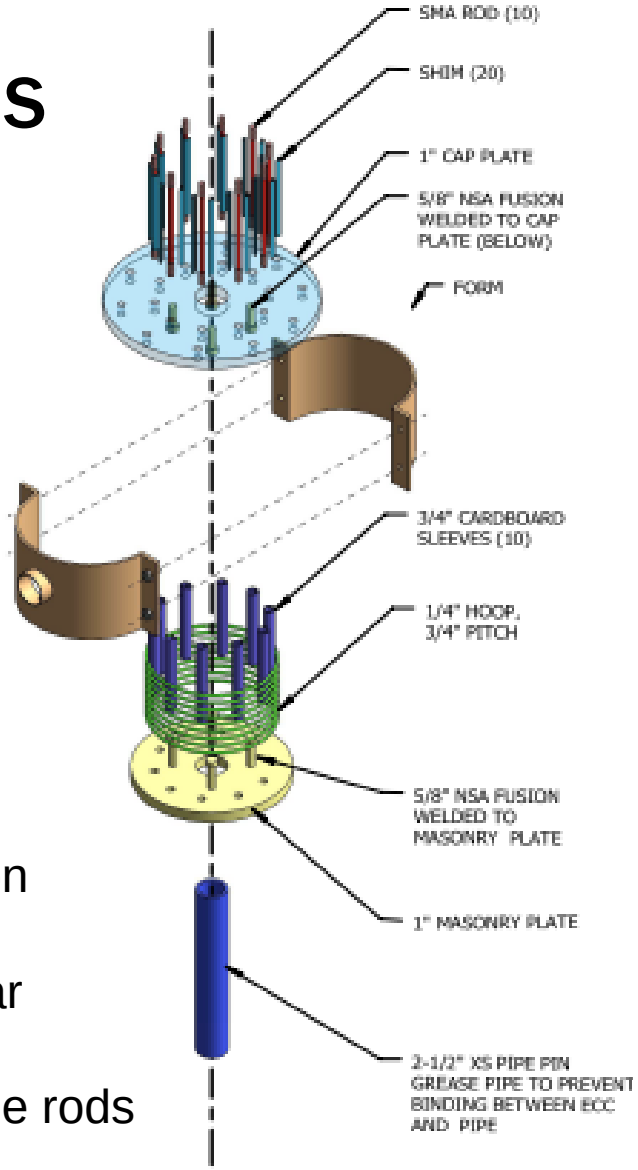
THE UNIVERSITY OF NEVADA RENO
COLUMN BASE UNIT



- This test unit was built by SCS's parent company, Fibermatrix.
- The unit was placed at the bottom of a single column representative of a bridge column.
- Results and Specifics are summarized in Dr Saiidi's presentation.
- Testing produced outstanding results for performance and repairability.
- Column has to be disassembled to access SMA rods.

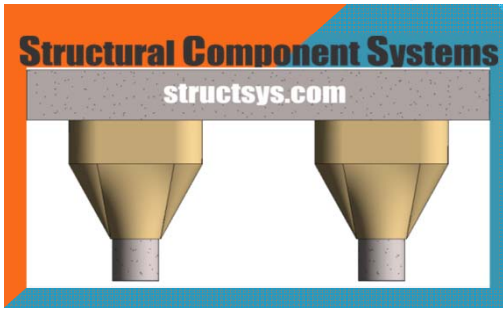
THE SDD: UNR AND SCS VERSIONS





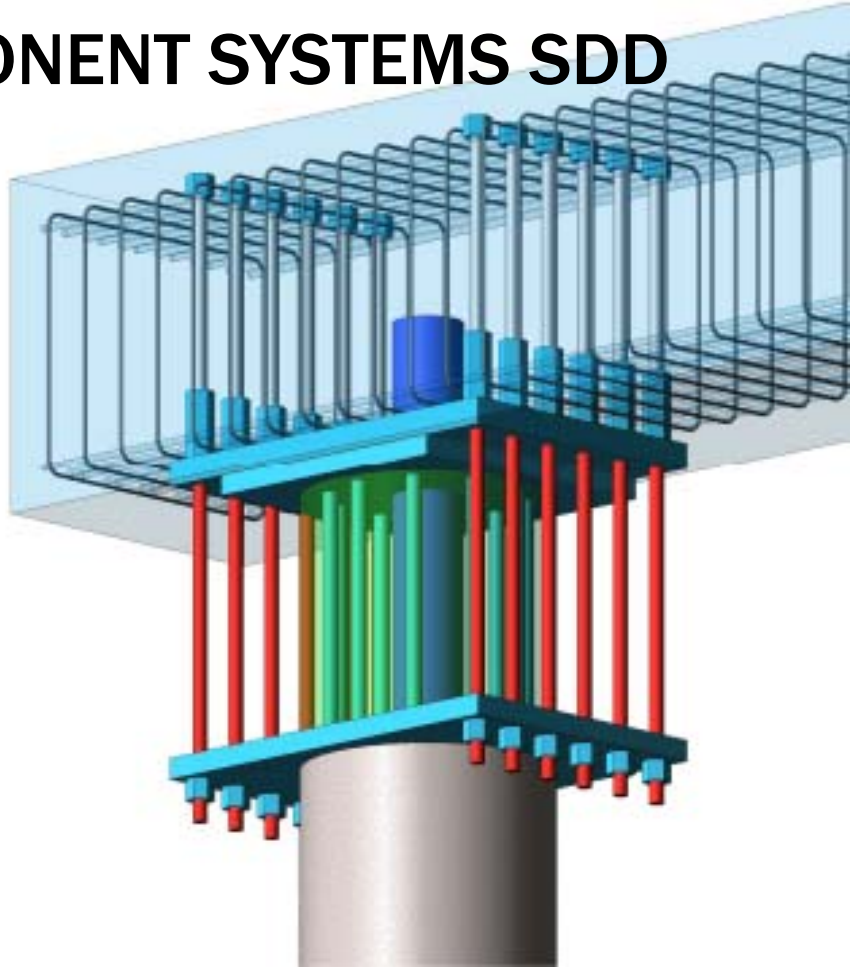
ECC carries compression
SMA carries tension
Shear pin transfers shear

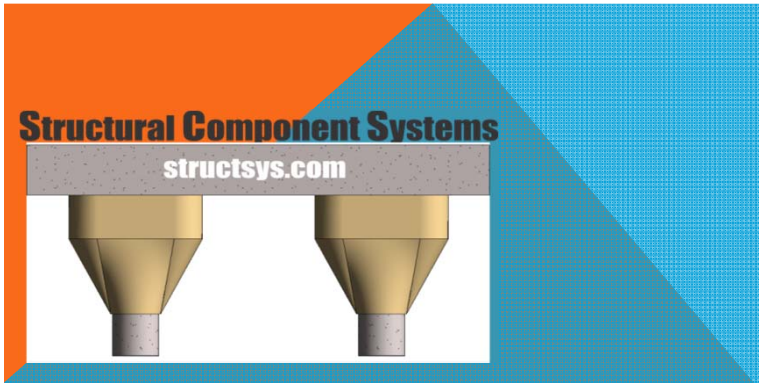
The SCS SDD moves the rods outside the column
The rods are protected by a non-structural fairing.



THE STRUCTURAL COMPONENT SYSTEMS SDD

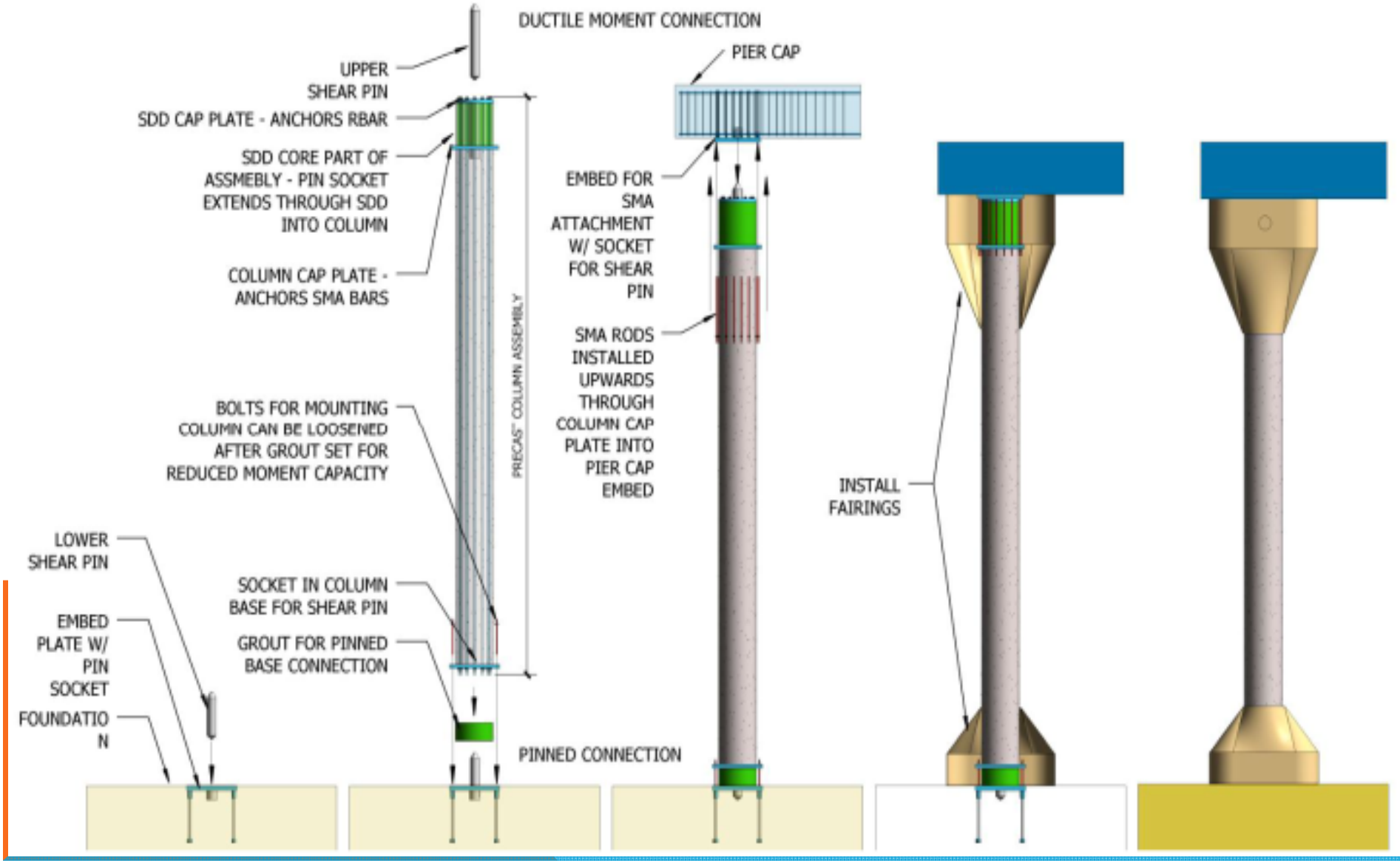
- Practical considerations place SDD between column and beam or column and foundation or both.
- The SDD uses the same concepts and materials as the UNR CBU.
- The SSD has a beam connection plate that has embedded rods into the beam. These rods are stronger than the SMA rods (in red) - thus the SMA rods will stretch before the embedded rods.
- The column rebar extend through the core and anchor in the top of the ECC core.



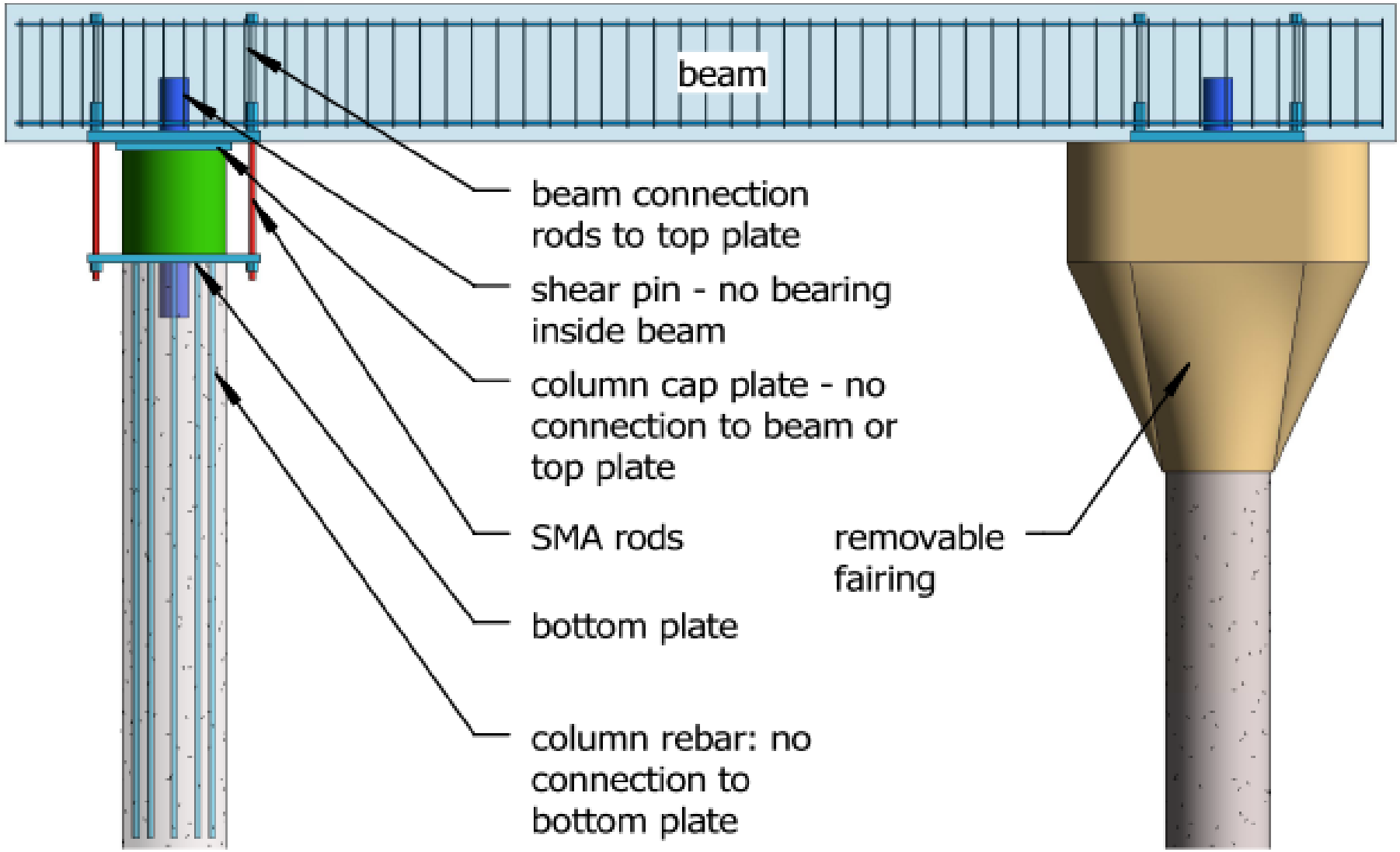


The SMA rods are outside the core and can be inspected and replaced from the bottom without taking the bridge out of service.

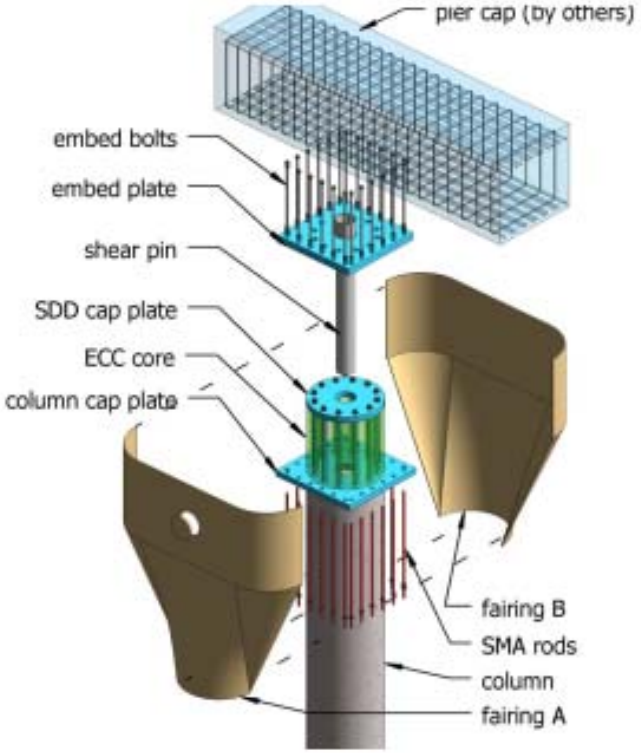
SCS SDD PRECAST COLUMN ASSEMBLY SEQUENCE

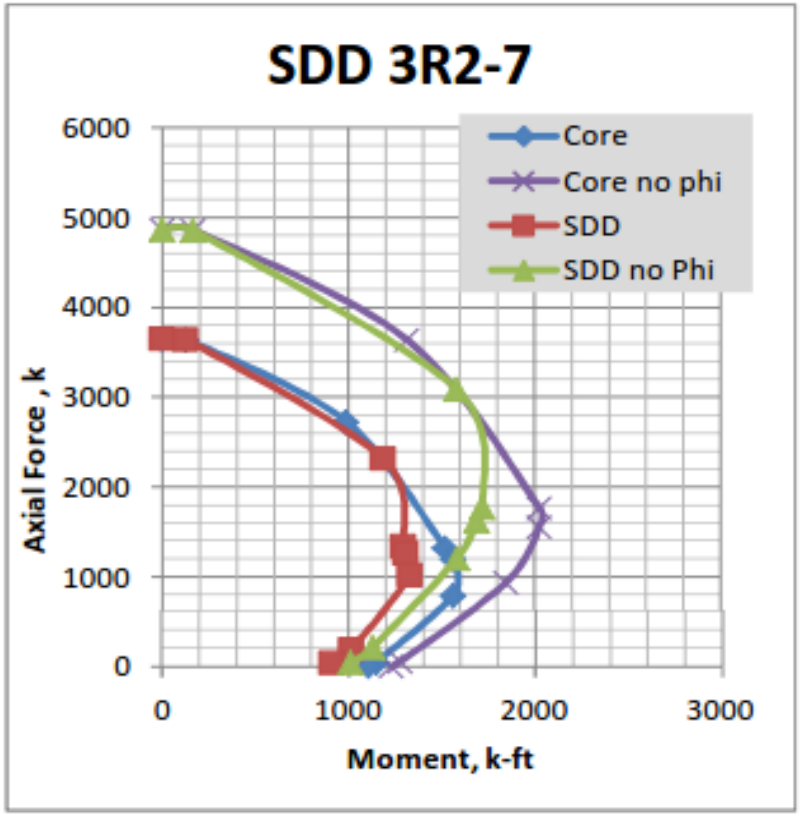


THE SCS SSD – ANOTHER VIEW



3’ DIAMETER, 2% AS SDD COLUMN EXAMPLE





Structural Component Systems
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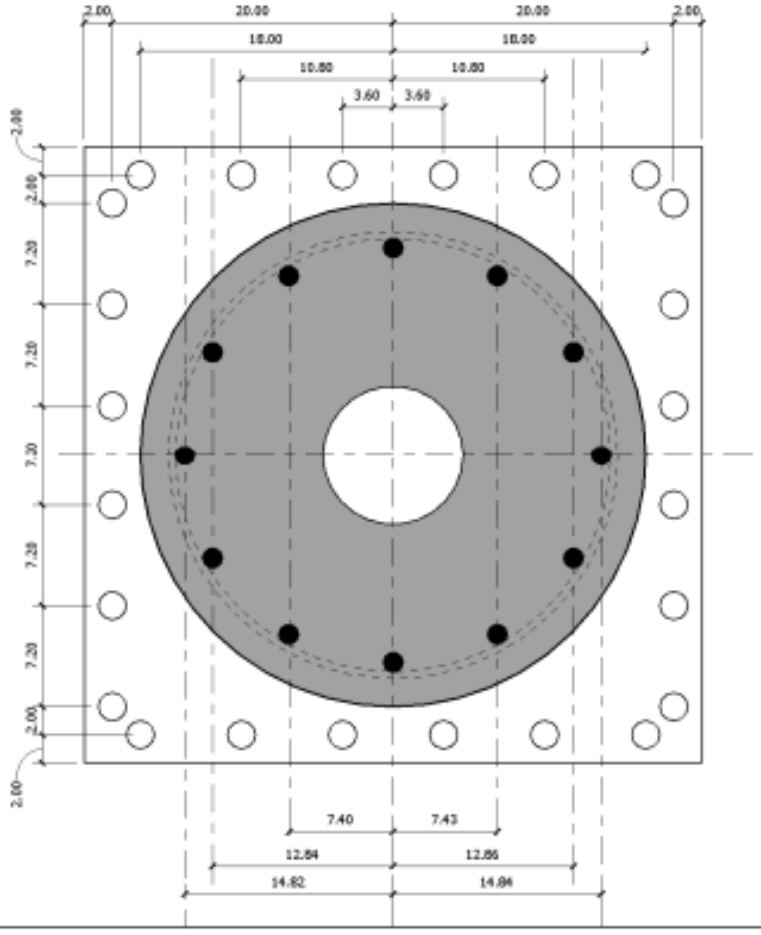
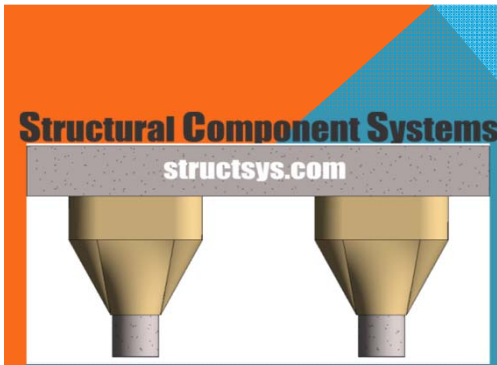
The interaction diagram shows that the SDD has characteristics nearly identical to the ordinary column until substantial moment is introduced. The SDD is then weaker than the ordinary column.

3’ DIAMETER, 2% AS COLUMN SDD EXAMPLE

Column Diameter	36 inches
SMA Pattern	40 x 40 square
Column Concrete f’c	5000 psi
Column Reinforcing Steel	(12) #11 ASTM A706 Grade 60
SDD ECC	5000 psi
SDD SMA	(24) #7 Nitinol Fy = 55 ksi; E = 5500 ksi
Column and SDD cap plate	ASTM A572 Grade 50
K_{eff}, SDD at SMA Yield	3064.2 x 10^3 k-ft/rad





SCS SDD PERFORMANCE AND STATUS

- **The SDD has structural properties identical to those of the column under normal conditions – no additional vertical deflections.**
- **The SDD is softer than the column, lengthening the period of the structure.**
- **The SDD's ECC and SMA components do not degrade.**
- **The SMA rods, which are the most likely portion of the SDD to be damaged, are easy to inspect and repair. As the SMA rods will not be active for ordinary gravity loads for most designs, replacement of the rods can be accomplished without taking the bridge out of service.**
- **The non-structural fairing allows architectural styling to be separate from structural concerns and provides an enclosed space for instrumentation or signage.**
- **Status:**
  - Patent application has been submitted to USPTO.
  - SCS is currently working with Granite Construction on SDD column assemblies as an alternative for bridges on a new highway – the Southeast Connector project in Reno/Sparks.