COMPOSITE REPAIR SOLUTIONS

December 3, 2025 | Tammy Bomia

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WHAT IS A COMPOSITE?

- Internet AI Definition:
  - "A composite material is a combination of two materials with different physical and chemical properties. When they are combined, they create a material which is specialized to do a certain job, for instance to become stronger, lighter or resistant to electricity. They can also improve strength and stiffness."
- Examples:
  - Cement: Crushed limestone & clay
  - Reinforced concrete: concrete & rebar
  - Particle Board: wood chips, sawdust & binder

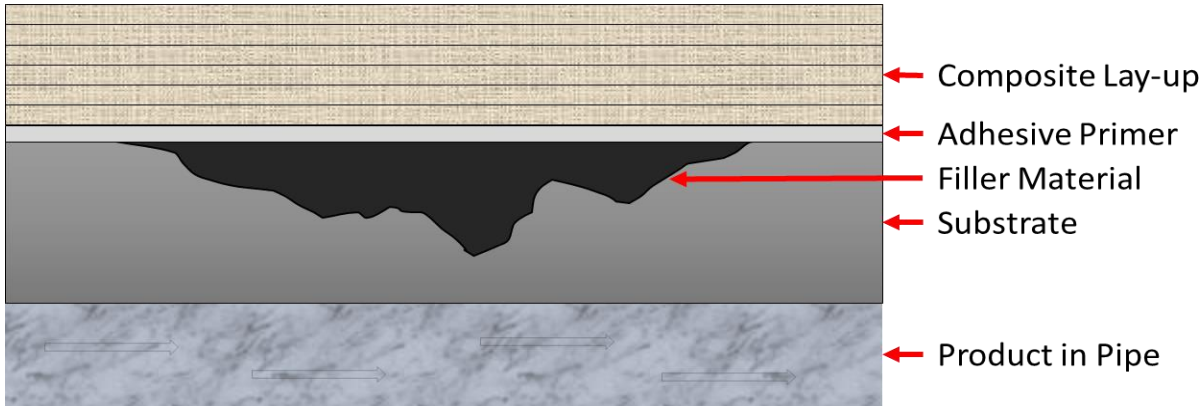
FUNDAMENTALS OF A COMPOSITE REPAIR

COMPONENTS

- Substrate (pipe)
- Load Transfer Filler
- Adhesive Primer
- Composite Outer Wrap

HOW IT WORKS

- Stress is distributed through the filler to the composite
- Stress absorbed by composite reducing strain in pipe
- Reduced strain means increased life



CODES & REGULATIONS

- **United States DOT CFR 192 and 195**
  - CFR 192.713, 195.585: "repair the pipe by a method that reliable engineering tests and analyses show can permanently restore the serviceability of the pipe"
- **CSA Z662 – complies with code and is considered a "permanent repair"**
  - Reference Clause 10.11.4.3 and Table 10.2 for specifics
- **ASME B31.1, B31.3, B31.4, and B31.8 allow for composite repairs**
- **ASME PCC-2 Article 401 and ISO/TS 24817**
  - Meets all required testing and provides basic design methodology
- **Det Norske Veritas (DNV), ABS and Lloyd's Register Type Approval**

ENGINEERED COMPOSITE REPAIRS FOR REGULATED PIPELINE INTEGRITY

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COMPOSITES FOR PIPELINE INTEGRITY

- **Rigid Coils**
  - Diameter specific
  - One size fits all – no design requirements

- **Pre-impregnated, Moisture Curable Urethanes (Pre-preg, MCU's)**
  - Fiberglass is saturated at the factory with a water-activated resin
  - Moisture tolerant
  - Odd geometries
  - Design for each repair required

- **Field Saturated**
  - Fabrics are manually saturated in the field
  - Very odd geometries
  - Design for each repair required

PIPELINE INTEGRITY

How far have composites come over the years?

When the first rigid system came out in the 1990's, handheld phones were popular

When pre-pregs came out in the early 2000's, handheld phones were smaller and had more capabilities

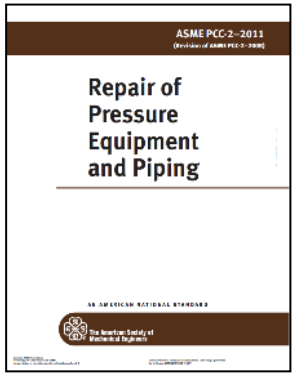
Field saturated, carbon fiber has been for 20 years and is tested, validated, and used for crack reinforcement, hard spots and other complex anomalies

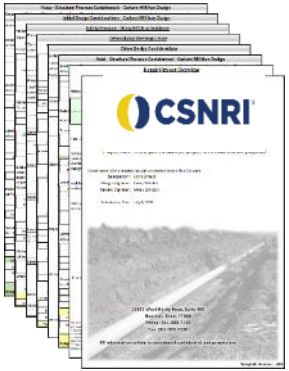
WHAT MAKES A REPAIR SYSTEM WORK?

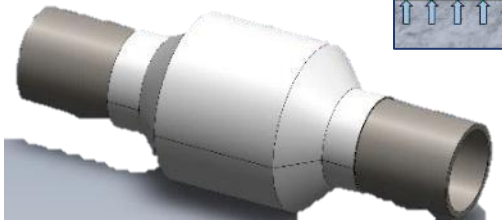
Sound Science…
- Polymer Chemistry
- Fabric Architecture
- Composite Design

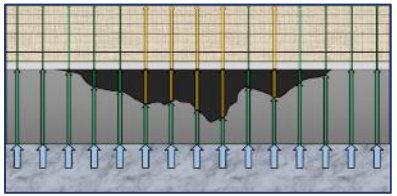
… proven through Testing
- Long-Term Testing
- Defect Specific Testing
- Third Party Certification

…and Designed correctly
- Engineering Design
- ASME & ISO standards
- Custom designs as needed
- Conservative – Safety factors

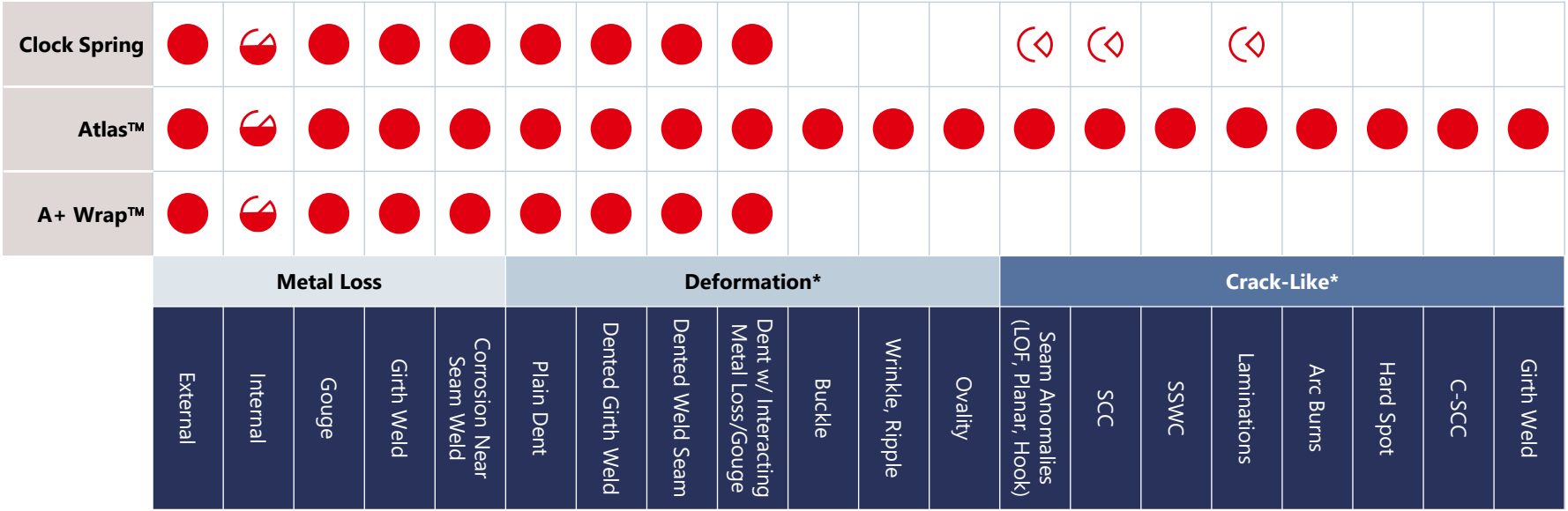








GENERALIZED PRODUCT PERMANENCY GUIDE



*permanency is dependent on defect size and cyclic profile

Permanent (50+ years) Temporary Permanent only if defect is mitigated

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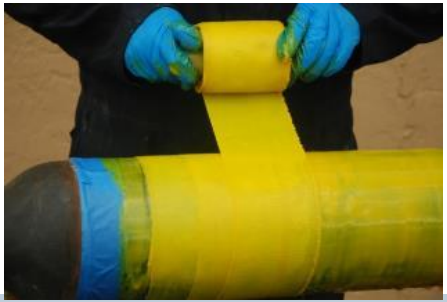
RELIABLE TESTING: 3RD PARTY VALIDATED

- Long-term Performance (10-year)
- Dented Weld Seam
- Vintage Girth Weld Reinforcement
- Repair of Dents Installing at Pressure
- 10-year rigid coil study
- Long term adhesive and cathodic disbondment testing
- Wrinkle Bend Reinforcement
- Reinforcement of Non-Leaking Crack-Like Defects using Composite Repair Materials
- 10,000hr Offshore Test
- Dent Validation (DVCIP)
- Selective Seam Weld Corrosion (SSWC)
- Stress Corrosion Cracking (SCC)
- Girth Weld Geohazard Reinforcement JIP

COMPOSITE REPAIRS ALTERNATIVES

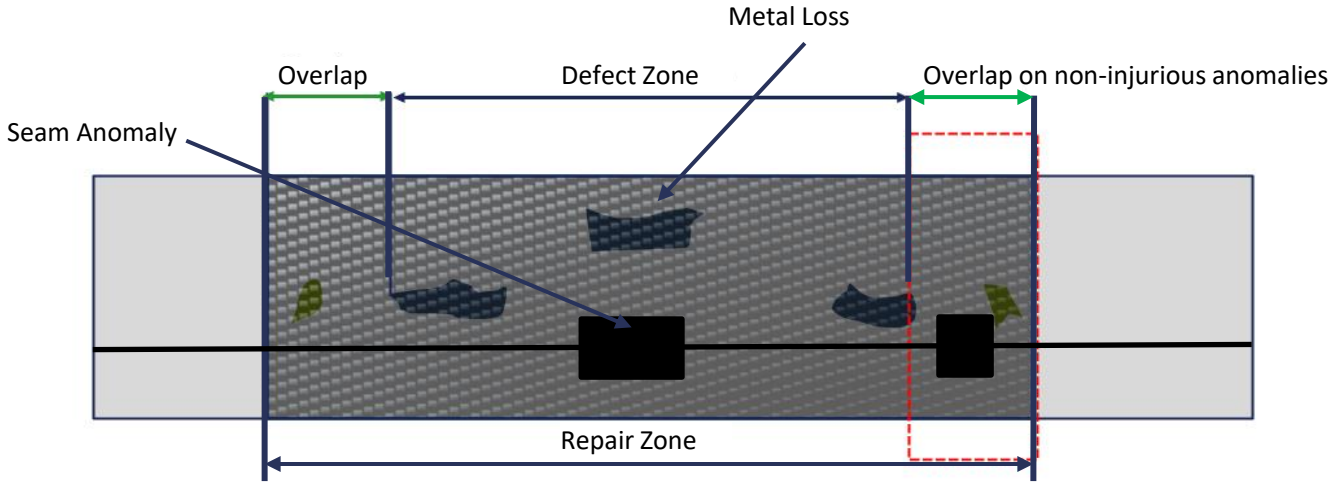
Steel Sleeves	Composites
Require good pipe, often difficult to find a landing zone	Do not require thick remaining wall to be installed
Ovality prevents a good fit for the steel sleeve	Do not require perfectly round pipe
Masks the defect to future ILI runs	Allow anomalies to be monitored
Heavier and may add additional axial stress	Composite repairs are faster, safer, and more flexible



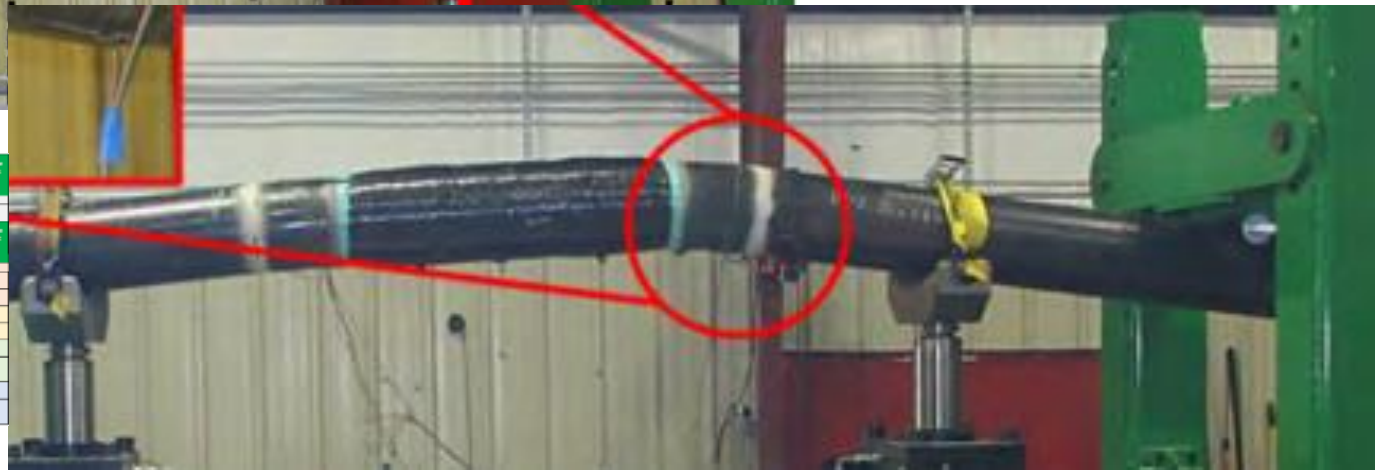



CLEAN LANDING ZONE

- Wrap can land over non-injurious defects
- Reduced repair zones and ditch lengths by 10’s to 100’s of feet



PERMANENT?

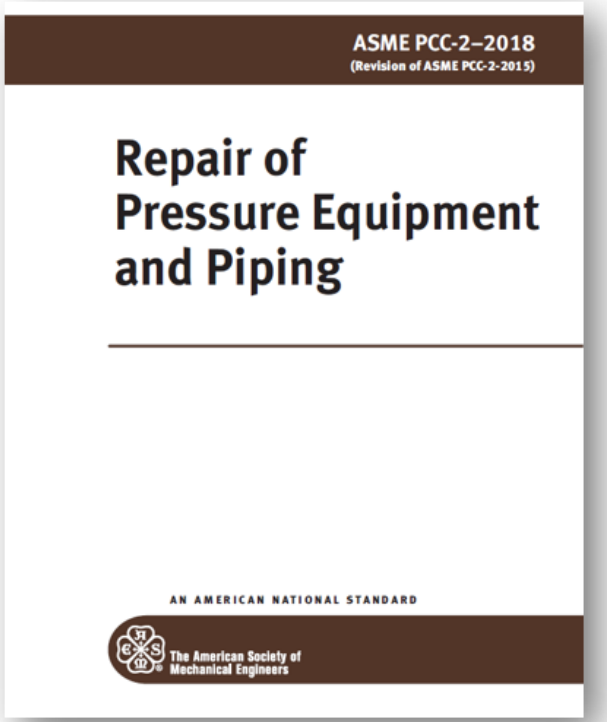


Sample No	Loading Condition	Total Bending Load (ft-kips)	Girth Weld Bending Load (ft-kips)	Maximum Deflection (in)	Maximum Measured Girth Weld Strain (%)	Maximum Measured Base Pipe Strain (%)	Girth Weld Strain at M_{max} (%)	Base Pipe Strain at M_{max} (%)
2	Unreinforced Bending + internal pressure	327	-	2.04	2.32	0.42	2.300	0.230
3	Reinforced Bending + internal pressure (P_{axial}=0 psig)	335	358	10.61	0.11	2.58	0.069	0.330

Sample No	Loading Condition	Total Axial Load (kips)	Girth Weld Total Axial Load (kips)	Maximum Elongation (in)	Maximum Measured Girth Weld Strain (%)	Maximum Measured Base Pipe Strain (%)	Girth Weld Strain at F_{max} (%)	Base Pipe Strain at F_{max} (%)
3	Unreinforced Axial tension + internal pressure	300	-	0.047	0.137	0.16	0.137	0.093
4	Reinforced Axial tension + internal pressure (P_{axial}=0 psig)	624	456	2.82	0.11	1.82	0.062	0.124
5	Reinforced Axial tension + internal pressure (P_{axial}=66% SMYS)	653	441	2.82	0.11	1.37	0.046	0.197
6	Reinforced Axial tension + NO internal pressure (P_{axial}=0 psig)	531	382	0.46	0.19	1.08	0.065	0.140
7	Reinforced Axial tension + NO internal pressure (P_{axial}=66% SMYS)	499	359	1.55	0.15	1.44	0.119	0.187
8	Reinforced Axial tension + 25,000 pressure cycles (ΔF = 36% SMYS) + internal pressure (P_{axial}=0 psig)	644	463	1.74	0.19	0.88	0.095	0.158
9	Reinforced Axial tension + 25,000 pressure cycles (ΔF = 36% SMYS) + internal pressure (P_{axial}=66% SMYS)	643	462	2.23	0.13	1.48	0.0837	0.134
10	Reinforced Axial tension + 250 axial tension cycles (ΔF = 50% SMYS) + internal pressure (P_{axial}=0 psig)	634	456	2.03	0.085	1.72	0.0638	0.181
11	Reinforced Axial tension + 250 axial tension cycles (ΔF = 50% SMYS) + internal pressure (P_{axial}=66% SMYS)	634	456	2.22	0.13	1.38	0.0647	0.233

CERTIFICATION / QUALIFICATION / SOC

- Type Specific Qualification
  a. installers shall be qualified for each specific repair system through practical tests for Type A and/or Type B
  b. specific approval tests shall be carried out with a written procedure, relevant to the specific repair system and approved by the repair system supplier
  c. qualification records shall be maintained by the employer of the installer



EXTERNAL CORROSION

Location:

- Arizona

Pipe Details:

- 30" OD, X56, .375" wall, Gas Transmission Pipeline
- 1008psi MAOP, Operating pressure = 680-875psi

Defect Information:

- Multiple external locations ranging from 0.5"-66" in length with wall loss from 41%-64%.

Application:

- Between 6 – 25 layers.
- Installations were completed in as quick as 30 mins – 3.5 hours with trained personnel and site supervision.
- Pipeline permanently restored to original strength without any issues of fit over the seam and girth welds

SEAM WELD LAMINATIONS

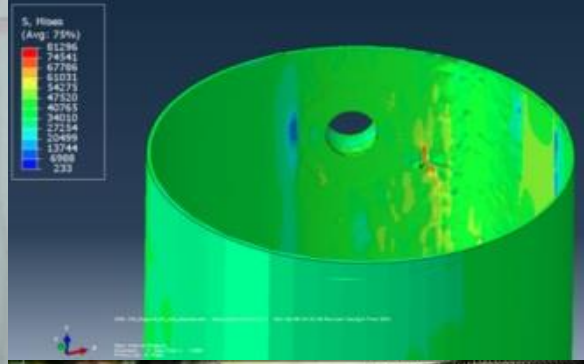
Location:
- USA

Overview
- Pipe Diameter: 12”
- Design Pressure: 1440 psi MAOP
- Pipe Contents: Refined products
- Pipe Defect: Lamination defect in the seam weld over 5% bend

Solution:
- Atlas engineered for 21’ repair length
- Installation Time: < half a day, backfilled same day
- Type B welded sleeve was not feasible repair solution through bend.
- Avoided down time, kept line in service, and restored pipe to original strength

VERY ODD GEOMETRIES

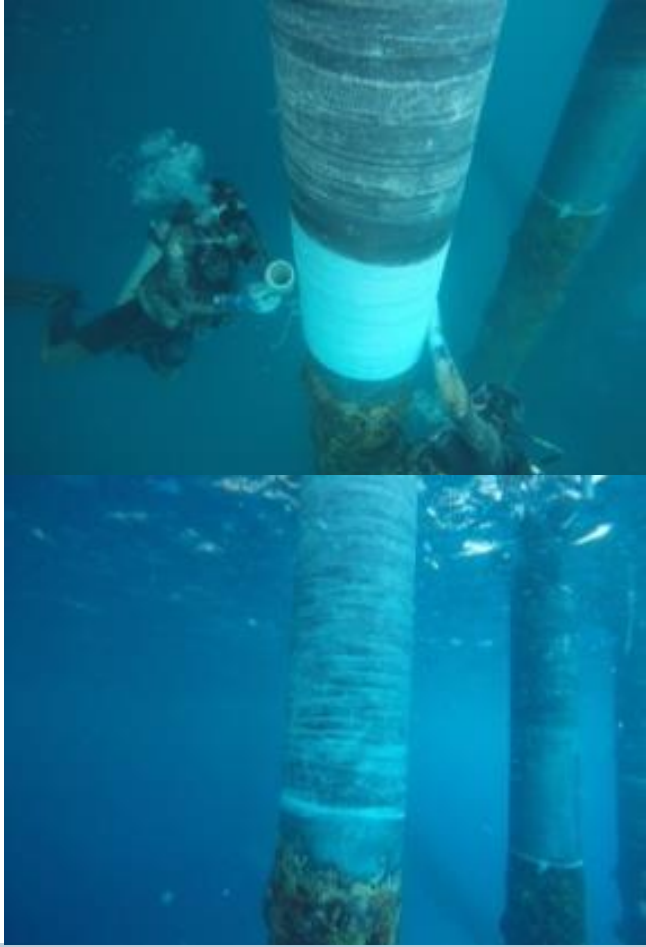
- 80″ Naphtha line
- 315 psi, 200°F
- MDEA vessel had severe internal corrosion
- FEA model collaborated to ensure proper reinforcement



SUBSEA

Project details

- Freeport, Bahamas
- Pipe Diameter: 20″, 24″, 30″, 36″ and 42″
- Operating Pressure: 200 psi
- Design Pressure: 200 psi
- Pipe Contents: Crude Oil
- Pipe Defect: External Corrosion



OTHER APPLICATIONS WHERE COMPOSITES ARE USED

COMPOSITES REPAIR SOLUTIONS

- External Corrosion
- Internal Corrosion & Leaks
- Mechanical Damage – Process
- Chemical Attack
- Leak Sealing
- General Corrosion & Minor Dents
- Mechanical Damage – Pipeline
- Crack and Crack-like Features
- Girth Weld
- Underwater Corrosion & Structural Damage
- Air-to-Soil Interface
- Pipe Supports
- Tank or Vessel Damage
- Distribution Lines
- Crack Arrestor
- HDD Protection
- Casing Spacer
- Residential Leak Repair

LIVE NATURAL GAS LEAK REPAIR

- No service interruption
- No relights
- Multi-meter sets
- Above & below grade
- Pressure limitations
- Temperature limitations

LIVE NATURAL GAS, LEAK REPAIR

Figure 21. Supply pressure check at end of test, 1028.6 hours @ 91 psig.

- 1000-hour
- Failure over 2000psi
- Only seepage

AIR TO SOIL INTERFACE – REPAIR OR MECHANICAL PROTECTION

CASING SPACERS

Casing spacers from old pipe

Casing Spacer cut to 5½" in width, installed as casing spacer

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PIPE SUPPORTS

HDD COATING PROTECTION

CRACK ARRESTORS

WHO TRUSTS CSNRI FOR PERMANENT COMPOSITE REPAIRS?

THANK YOU

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