# Characterizing the Sensing Orthopedic Cast Material in Bending

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**Abstract:** In this study, the effect of bending stress on the modified orthopedic cast material was investigated. The standard Plaster of Paris was modified with conductive filler to make it piezoresistive. Since thin sheets of Plaster of Paris are used in medical casting, it will be important to characterize its behavior in bending. The change in resistivity with application of point load of 176 lbs on 0.047-inch-thick plates supported around the circumference was 15% while for thin plate with thickness if 0.032 inch, it was 9.8% a point load of 118 lbs.

## 1. Introduction:

Plaster of Paris was first widely used chemically, surgically and in construction works in Paris, France. Plaster of Paris is produced by removing the impurities from the mined gypsum and then heating it under controlled conditions to reduce the amount of water of crystallization. Plaster of Paris was well known as a building material for many centuries before it was introduced as casting material. Egyptians as well as Romans used it for plastering walls (Browne et al., 2008).

Plaster of Paris is chemically represented as calcium sulphate with water ($2CaSO_4.H_2O$). It is prepared by heating gypsum ($CaSO_4.2H_2O$) at 120°C to allow partial dehydration. When mixed with water, it gives out heat and quickly solidifies within 5 to 15 minutes. The stage 1 is called the setting stage with a slight expansion in volume. The stage 2 is the solidification.

Stage 1: Plaster of Paris formation

Stage 2: Solidification- $2\,(CaSO_4 \cdot \frac{1}{2}\,H_2O) + 3\,H_2O \rightarrow 2\,(CaSO_4.2H_2O)$ + Heat

Its first documented medical use dates back to 1852 when A. Mathyson, a Dutch Army Surgeon, rubbed powdered plaster into cotton bandages to form splints. The first use of plaster of Paris as a cast for injured limbs took place through a technique known as plâtre coulé that became popular in Europe at the beginning of 19th century (Szostakowaski et al, 2017) Application of plaster of Paris requires good knowledge of anatomy and pathology that are being treated. It has to be applied with great care and also need in its supervision afterwards. There are a number of complications that relate to long periods of immobilization which include joint stiffness, muscle atrophy, cartilage degradation, ligament weakening, and osteoporosis (Stefanie at al., 2011). Some risks can be minimized with correct Casting Monitoring Technique

**2. Objective:** The main objective was to quantify the changes in the electrical resistivity for the effect of mechanical stress for orthopaedic cast material.

## 3. Materials and Method:

Commercially available Plaster of Paris (POP) was used for characterizing the cast material. The Plaster of Paris was modified with conductive fillers to make it a piezoresistive material. The POP was modified by adding upto 0.05% of conductive filler (CF), by weight of the plaster of Paris. The water to plaster ratio used was 0.5. The Plaster of Paris slurries were prepared using hand mixing by adding POP in stages into the water. First, measured amount of mixing water was poured into the container. Then little amount of conductive fillers were added to the water and then a little amount of POP was mixed to the mixture. Then little by little POP and conductive fillers were gradually added to the container and mixed for about 1 minute so that it could be properly dispersed in the mixing water. After mixing, POP specimens were prepared using cylindrical molds and circular plates. The Cylindrical molds are 2 inches in diameter and a height of 4 inches. Circular plates of 3.65 inch diameter with thickness of 0.047 inch and 0.032 inch were also prepared for the bending test.

Bending Test: This test was performed on plate specimen using point load at the center with compression testing machine. The point load was recorded with the change in resistivity of the POP material using the impedance meter as shown in Figure 1.

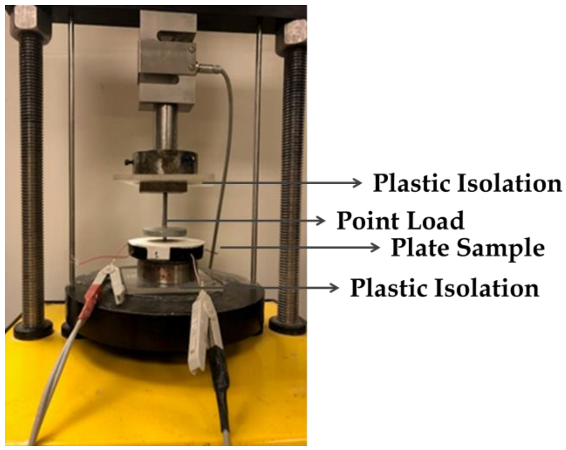


**Figure 1: Plate Bending Test Apparatus**

## 4. Results and Discussion:

**Density**

The density of the POP samples with and without conductive fillers was about 1.1 g/cc.

**Resistivity**

Initial resistivity of cast material without conductive filler was 3.3 Ω-m immediately after mixing while it was 1.46 Ω-m and 0.9 Ω-m with 0.02% and 0.05% of conductive filler.

**Bending Test**

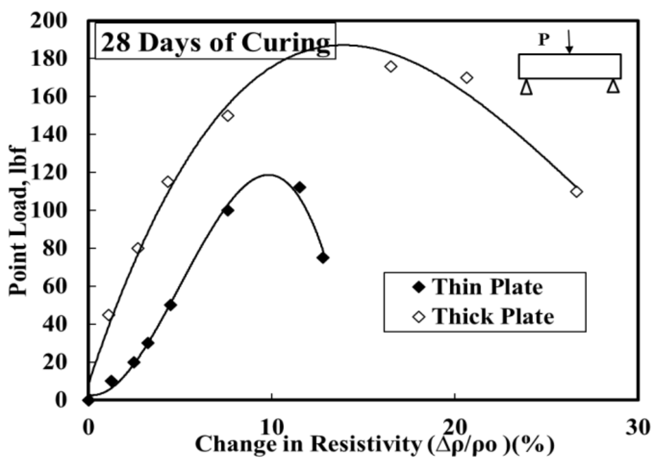


**Figure 2: Change in resistivity with application of point load at the center.**

The change in resistivity for the thick plates was 15% at a point load of 176 lbs at the center while the change in resistivity for thin plates was 9.8% for 118 lbs. of point load at the center. (Fig. 2) The change in resistivity per pound of point load varied from 0.083 to 0.085%/lb and was maximum for the thick plate because of higher load capacity. The thin plate showed more change in resistivity at the same applied load, making it more sensing.

## 5. Conclusion:

For the disk specimen with 0.047-inch thickness the resistivity change per pound of bending load varied from 0.083 to 0.085%/lb and the thin plate was sensitive for the same point load applied.

## 6. Acknowledgements:

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## 7. References:

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