Prototype of Making Endpost Rail Joint on Railroads Made of CFRP (Carbon Fiber Reinforcement Plastic)

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Abstract. Endpost is a component that separates two connected rails to prevent a short circuit in the rail line. The purpose of the research was to improve the mechanical properties of the endpost in terms of pressure and the value of electrical insulation. The study used an experimental approach, aiming to determine the increase of the mechanical properties of the endpost made of carbon fiber with various compositions. After making the endpost composite specimen, it carried out a compressive test and an insulator resistance test to determine the maximum load strength and stress of the composite endpost. From the compressive test and the insulator test, it obtained the maximum pressure at 7.00 Mpa based on the 80%:20% epoxy-carbon fiber composition which had the highest pressure strength value of several test specimens in the compression test. And, the endpost composite insulator resistance test, the endpost composite specimen obtained a resistance value of 50 kΩ in a voltage test of 250 kV.

1 Introduction

With the development of the times, the application of composite materials in the engineering field is increasing. The fact is caused by the superior properties of composite materials compared to other conventional materials. The advantages of composite materials are their lightweight and higher strength, good mechanical properties, durability, corrosion resistance, ease of manufacture, and relatively low production costs. Various composite materials include the type of carbon fiber composite. Carbon fiber is a composite material used for manufacturing because it is very strong, yet lightweight. Carbon fiber-reinforced composites are often used for the manufacture of materials that are lightweight, readily available, and commonly used by society and industry. This composite has the characteristics of being extraordinarily strong, lightweight, and not easily brittle. The addition of a carbon fiber layer to the composite material will increase the fiber weight fraction and fiber volume fraction, which make increases in the strength and high modulus of the composite material.

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The manufacture of composites in the railway sector is relatively large. But, the fabrication technique is quite simple, namely by combining materials to make a composite. One of the important components made of composites is the endpost which is used as a stray electric circuit breaker on railroads. Rails are made of steel material that can conduct electric current, resulting in wild electric currents and lightning strikes. Therefore, it needs to use electrical insulators by installing isolated rails and endposts on the rails to reduce the risk of stray electric currents that can interfere with the electronic signal system (Kuntari et al., 2011).

There are cases of damage and interference to one of the components of the railway line in the Operational Area (Daop), precisely in Daop 3 Cirebon. One of the damages is the endpost. Damage to the endpost occurs based on findings at certain location points with documented evidence of the damage to the endpost components. Endpost or commonly known as an insulating rail is an insulating component that functions as a separator between rails where if there is no insulating rail, there will be interference as different rails will result in interconnected polarity (Mandal & Peach, 2010). The location of the endpost is in the gap between the adjoining rails and is always passed by the train wheels. Endposts are the weakest component of the rail, with a service life ranging from one-third to one-half of the rail life and depending on usage. If it is damaged, it must be replaced immediately.

A factor causing endpost damage is the rails shrink at night which causes slack at the ends of the rail edges and creates gaps in the rails. When the train passes through the gap, the train wheels will apply direct pressure and cause damage to the endpost structure. If the gap is more tenuous, then it accelerates damage or wears out quickly. This interferes with the track because the polarities on the 2 rails will be connected. Damage to the endpost can be influenced by many factors, such as the materials. In addition to being an insulator, the endpost must also have the characteristics of mechanical properties following the endpost function of cannot conduct electric current (Dangre, 2019).

Based on the description, each endpost material has different quality and reliability, so it needs to make an endpost that has strong quality and resistance compared to the previous material. For this reason, research was carried out on a prototype for making endposts on railroads made of CFRP (Carbon Fiber Reinforcement Plastic). The problem limitations of the study are the basic materials of manufacture using carbon fiber reinforcement plastic, knowing the characteristics of carbon fiber reinforcement plastic used as endpost composites, manufacturing using the press method and making test specimens on compressive testing and testing of insulator resistance according to standards. The purpose of the study was to determine the quality and strong resistance using carbon fiber and epoxy resin as basic materials and to determine the results of compression testing and resistance testing of the prototype endpost rail joint insulator on a railroad line with carbon fiber reinforcement plastic as the base material.

2 Research Method

2.1 Literature Study

The study used materials sourced from literature studies by exploring written sources such as books, journals, or other documents that have relevance to the topic and the problems of the research. After studying the literature, the next step is to determine the composition using the trial and error method, namely by trying several different compositions and choosing a composition. While the data collection technique is by using a trial model or experiment using several test specimens. This study produces data from compression testing with the ASTM D695 standard and insulator resistance testing to obtain data that is processed, analyzed, and concluded.

2.2 Preparation of Materials and Tools

The study made an innovation on composite endposts using a composition of carbon fiber and epoxy resin. In this case, it requires several materials and tools, such as mold release, carbon fiber reinforcement plastic (CFRP) or carbon fiber, epoxy resin+catalyst, and molds, hydraulic presses.

2.3 Specimen Making Method

The stages in making endpost specimens are carried out using the press method, which is when the composite material is made, and the pressure is applied after pouring the composite material into the mold. The technique aims for the composite material to become solid and follow the shape of the mold.

2.4 Press Test Method

The test is a compression test. The tool in the testing is a universal test machine (UTM) with a model TarnoTest Grocki UPH 100 Kn, a capacity of 10 tons in 1982. This material testing machine is used for testing materials such as tensile tests and compressive tests. A universal test machine has a microcontroller device that functions to connect to a computer, aiming to produce documentation from the system, by computerizing it to study the level of reliability of the system created. This test aims to know the mechanical properties of the alloy of the two materials. Tests were carried out on each variation of the endpost specimens made from carbon fiber reinforcement plastic and epoxy resin.

2.5 Insulator Resistance Test Method

In this test, direct observation was carried out, namely at the station emplacement of the Indonesian Railways Polytechnic Madiun. The locations reviewed for testing include the advanced signal environment. A mega ohm meter (Megger) BM 5200 is used to measure the insulation resistance. The insulation part - to be measured - is the isolation between the voltage and non-voltage parts, such as the body or ground. The test was carried out with an experimental voltage of 250 kV using a megger measuring instrument which aims to see the ability of the insulating material. The test is carried out by attaching a test cable to the rail between the IRJs that have endposts. Then, it selects the required measuring scale. In this study, it selected a 250 kV measuring scale with a good megger measurement standard of at least 1000 Ω/Volt.

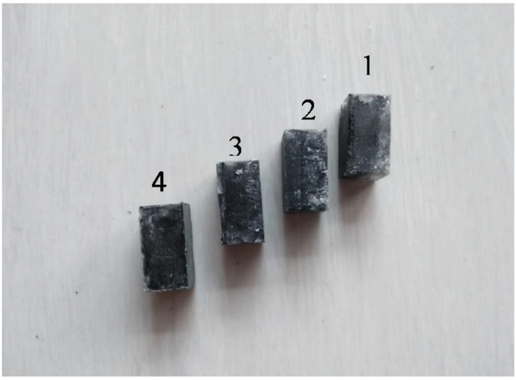

Fig. 1. Specimen Endpost

Table 1. Compression test results of carbon fiber composites with epoxy resin

Specimen		Thick (mm)	Wide (mm)	P (N)	Max compressive load
Alloy	to				
95%:5%	1	12,7	25,4	2111	6,54
90%:10%	2	12,7	25,4	2047	6,34
85%:15%	3	12,7	25,4	2168	6,72
80%:20%	4	12,7	25,4	2260	7,00

3 Result and Discussion

3.1 Results of Making Specimen

The process of making endpost composites on railroads made of carbon fiber with a mixture of epoxy resin was through several steps. It begins with the preparation of materials and tools, namely carbon fiber and epoxy resin. Composite manufacture is begun by calculating that aims to determine the composition of each material. Then, the process of making composite specimens uses the press method, which is to press to compact the composite material. Figure 1 is an endpost specimen that has been pressed from the press machine mold.

After making the composite specimen, the next process is to conduct a compression test and an insulator resistance test to analyze the obtained results.

3.2 Press Test

Based on the calculation results of the compressive test of carbon fiber reinforcement plastic (CFRP) composites with epoxy resin, the data are presented in Table 1.

The compression test of the endpost prototype with various epoxy-carbon fiber resins produces different strengths. The first specimen is 6.54 MPa. The second specimen is

Fig. 2. Insulator resistance test

6.34 MPa. And, the third specimen is 6.72 MPa. Meanwhile, the fourth specimen is 7.00 MPa. The smallest maximum compressive load of the four specimens is the second specimen with a strength of 6.34 MPa, while the largest compressive load is specimen 4 with a strength of 7.00 MPa.

3.3 Insulator Resistance Test

The insulation resistance test on the composite endpost was carried out at the station emplacement of the Indonesian Railways Polytechnic Madiun, especially at the IRJ signal advanced by conducting a voltage test of 250 kV on the composite endpost. The insulation resistance test is carried out directly in the line using a megger tool, aiming to find out the results of the resistance value of the endpost composite. The insulation resistance test obtained a resistance value of 50 kΩ. These results were obtained through measurements with the megger BM 5200. An insulator resistance test carried out on the line is presented in Fig. 2.

3.4 Discussion

Based on the calculation of the volume fraction, it determined the composition of the amount of epoxy resin and carbon fiber from the size of the mold volume with a value of 4096 cm3. Calculation of the volume fraction between epoxy resin and catalyst uses a ratio of 1:1, by the provisions of the rules listed on the product. The composition of the first composite material that uses a volume variation of 95% epoxy resin and 5% carbon fiber, obtain the composition value of epoxy resin by 4.39 g and carbon fiber by 0.34 g. The composition of the second composite which uses a variation of 95% epoxy resin and 5% carbon fiber, obtains a composition value of epoxy resin by 4.39 g and carbon fiber by 0.34 g. The composition of the third composite which uses a variation of 85% epoxy resin and 15% carbon fiber, obtains a value of epoxy resin by 3.93 g and carbon fiber by 1.04 g. The composition of the last composite which uses a variation of 80% epoxy resin and 20% carbon fiber, obtains a composition value of epoxy resin by 3.70 g and carbon fiber by 1.39 g.

After calculating the composition of the material, the specimens are made in stages. After that, it tests each specimen to determine the compressive strength of each different material. In the first specimen at a volume fraction of 95%:5%, epoxy-carbon fiber resin accepts a pressure load up to 6.54 MPa. In the second specimen at a volume fraction of 90%:10%, epoxy-carbon fiber resin accepts a compressive load up to 6.34 MPa. In the third specimen at a volume fraction of 85%:15%, epoxy-carbon fiber resin accepts a compressive load of up to 6.72 MPa. The fourth specimen at a volume fraction of 80%:20%, epoxy-carbon fiber resin accept a compressive load of 7.00 MPa.

The volume of the mixed mixture in each specimen affects the strength of each maximum compressive load on each specimen as it is influenced by the mixture of the two materials, namely carbon fiber and epoxy resin. Carbon fiber has advantages, such as strong to very strong, stiffness, small expansion coefficient, and resistance vibration. The more carbon fiber used in the base material and the less resin and catalyst used, the stronger the specimen. This comparison is seen by the fourth specimen at a volume fraction of 80%: 20%, epoxy-carbon fiber resin can accept the highest compressive load up to 7.00 Mpa. It showed by the previous graphic data that the maximum pressure on the alloy which has the biggest maximum is carbon fiber with 80%:20% epoxy resin. The tests follow the ASTM D695 standard. In the insulator resistance test on the endpost composite material with a voltage test of 250 kV, the endpost composite specimen obtained a resistance value of 50 kΩ, which means, that both endpost materials are still good insulators.

4 Conclusion

After performing calculations and analysis of the data and the results of the compression test on CFRP carbon fiber reinforcement plastic composites with an epoxy resin alloy, it concluded the making of carbon fiber reinforcement plastic composites with epoxy resin using the press method. The results obtained from the composition of 80%:20% have the highest value of 7.00 MPa from several other test specimens. The tests follow the ASTM D695 standard.

Furthermore, it obtained the results of the insulator test on endpost composites made from carbon fiber reinforcement plastic. This test uses a voltage of 250 kV. And, it obtains a resistance value of 50 kΩ. The test was carried out using a megger to determine the results of the resistance in the endpost composite made.

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