Overhead Conductor (ACCC) Failure on Live Line in Indonesia

ACCC was broken and composite core (① + ②) fractured complicatedly.

① Carbon composite (Carbon fiber with epoxy matrix)
② Grass fiber coating layer
③ Annealed Aluminum wires

1. Outline
Nobody expects sudden conductor breakage of the live line in the overhead transmission lines, however it is reported that several projects in Indonesia, Poland, China, India, Mexico, and the U.S. etc. faced the serious accidents caused by the conductor breakage of aluminum overhead conductor with composite core reinforcement (so-called Aluminum Conductor Composite Core: hereinafter abbreviated “ACCC”) under the conditions of live line operation within the short period after completion of conductor installation.

Above photos show the appearances of ACCC breakage, which recently happened in Indonesia on November, 2010. This accident happened suddenly during normal operations on the approx. 10th day from the completion of installation works of ACCC. Keen attention should be paid to the fact that none of aluminum component wires nor conductor surface were damaged during the installation works, while whole conductor was broken. It is analyzed that the composite core housed inside the conductor was firstly broken due to certain stress or defects, and then the component wires of annealed aluminum were broken due to over-loading stress without composite core reinforcement. It is obvious that the breakage of composite core was derived from the really critical nature of carbon composite core, such as brittleness, inflexibility and so on, as the tension member of overhead conductor even if under ordinary installation works.

The difficulty for this ACCC conductor is that there is no way to judge nor to prove if the all installation work along with the whole conductor length was correctly and successfully made or not, by that the completed transmission line should be always exposed to the risk of sudden conductor breakage. In due consideration of the operation and maintenance work for overhead transmission lines, this kind of conductor is quite dangerous and not applicable for highly reliable overhead transmission lines.
2. Detailed explanation and pictures

Figure 1 and 2 shows the broken ACCC and a tension tower. These pictures show that the broken point was apart enough, approx. 20 m, from the dead-end clamp, indicating that the broken point may not be touched in the sagging works on the tower. Figure 3 shows the other side of broken ACCC, which was dropped to the ground. Fortunately, there were no objects under the transmission line, but if there were something like houses, humans and traffic, it would be hazardous results.

![Fig. 1 Broken ACCC with tower.](image1)
![Fig. 2 Broken point of ACCC](image2)

![Fig. 3 The other side of broken ACCC was dropped from the tower to the ground.](image3)

Figure 4 is close-up photo of the broken surface of ACCC. There are two important points in this picture:

#1 The outer surface of aluminum wires were not damaged.

#2 The shape of the broken aluminum wires clearly indicates ductile fracture due to the tension in a longitudinal direction.

It is obvious that the broken point of ACCC was not directly damaged by some sagging tools nor incorrect...
handling through the installation works.

Thus, this ACCC breakage was started from the carbon composite core fracture, and then all tension would be transferred to aluminum wires and aluminum wires were fractured completely. Carbon composite core seems to be very sensitive to the external force from standard installation and manufacturing process because the ACCC was actually broken but the aluminum strands seemed not to have been damaged, that is, it was very difficult to expect conductor breakage because there was no damage on the conductor surface.

Fig. 4 Close-up picture of broken ACCC. Red elliptic circle points no-damaged outer strands and blue square points the feature of ductile fracture of aluminum wires.

Fig. 5 Broken surface of carbon composite core and aluminum wires
3. Summary

The followings are summary of the facts observed from the reported photos and information supplied by the concerned parties on the performance and reliability of ACCC in the field of actual overhead transmission lines:

1) ACCC had sudden conductor breakage on the live line operation of overhead transmission line in Indonesia. From the investigation and analysis of the sample and photos, it is quite obvious that the breakage was not caused by the direct damage on the conductor surface nor component aluminum wires, because the appearances of both broken ends of all aluminum wires showed so-called “ductile fracture” from the metallurgical viewpoints. On the other hand, the composite core was apparently broken as like as “abnormal fracture”, which caused aluminum component wires over load. It is reported that this accident happened within very short period, that is, after approx. 10th day from the completion of installation work. The cause of composite core breakage is not always clear, however it is undoubtedly said that the property of it is very sensitive to the external force/stress of bending and twisting to be expected during the ordinary installation work.

2) It is widely known that ACCC had several similar conductor breakage troubles during the installation work at site and also on the live line within short period after completion of installation. For example, the conductor breakage troubles during installation are reported in USA, CHINA etc. and the serious conductor breakage on live line at the project in POLAND.

3) The difficulty of ACCC conductor results from the conductor construction, i.e., “brittle tension member of composite core is housed inside, while soft annealed aluminum wires are stranded outside. Furthermore, the composite core consists of single wire with large diameter, by that any single defect such as foreign object in material provides the possibility of composite core breakage by bending, for example, through the stringing sheave passing, etc.” It is actually quite difficult to judge or prove from the conductor surface if the installation work is appropriately done along the all conductor length without such excess bending or twisting. Contrastively to ACCC, conventional conductors like ACSR (with steel wire reinforcement) have stable properties to withstand against bending/twisting up to certain practical level for ordinary installation work. From the viewpoints of above, it is really said that carbon composite materials as the tension member of overhead conductors is still at the stage of premature and risky, particularly in the application of important transmission lines.

To conclude, ACCC conductor is regarded as premature and risky in the practical application for overhead transmission lines. One of the crucial points for applying composite core conductors on the practical transmission line is that there are always possibilities of sudden conductor breakage because it seems that detecting the defects on composite core, which are originated from installation works, is still really difficult.