AACSR – The Forgotten High Strength, Low Sag Conductor

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Abstract
What are the considerations, issues, and solutions presented when you’re faced with rebuilding a long transmission span across an ever-changing riverbed? This paper will explore how OG&E and CEC handled the rebuild of the Fixico-Kolache transmission line crossing the Canadian River. Specifically, we’ll discuss how the project was initiated, how CEC & OG&E developed solutions and selected the best option for everyone involved and how CEC & OG&E spanned the river by using a custom design with specialized conductor.

The washed-out structure was discovered during regularly scheduled inspections as part of a program called Transmission Restoration. Transmission Restoration is a vital maintenance program at OG&E where inspectors inspect existing Transmission lines for areas of concern. CEC inspectors carefully assess each structure and make recommendations for repair, reinforcement, or replacement. The Fixico-Kolache 69kV Canadian River Crossing project emphasizes the importance and benefits of regular inspections of a utility’s infrastructure.

We will also explore the decision-making process for how to re-build the river crossing. OG&E and CEC evaluated multiple options for relocation of the line, and we’ll showcase the reasons why each of those options were eliminated. Details considered in making the decision included timeframe, ROW issues, environmental considerations, and the desire to eliminate any structures being placed in the riverbed.

After the decision was reached to span the entire riverbed, CEC and OG&E’s Transmission Engineers had to take this plan from conception to reality. After CEC’s survey crew provided a land survey showing the extents of the Canadian River, the group was now faced with a 2,550’ span. This long span presented many obstacles including vertical clearance, conductor spacing, structure strength, galloping, vibration, sag of the conductor, conductor strength, ice loading, constructability, and possibly FAA paint and lighting requirements. In order to avoid the FAA requirements and future maintenance they would impose, CEC and OG&E decided to use a special high strength AACSR conductor to reduce sag and allow for shorter poles.
**Project Definition**

Oklahoma Gas and Electric (OG&E) has an ongoing transmission maintenance program called Transmission Restoration. As part of this program they contract with CEC Corporation (CEC) to perform walking inspections of their transmission lines. Two CEC inspectors were inspecting the Fixico to Kolache 69kV line when they discovered an h-frame structure barely hanging on. The changing course of the Canadian River was washing away all the soil around the structure’s foundation. To make matters worse, the old course of the river and the new course of the river had surrounded the location of the structure, turning this patch of ground into an island as shown in Figure 1 below. The structure couldn’t be replaced in the same location or even close by. This stretch of line would have to be redesigned to make ongoing maintenance possible.

**Figure 1**

![Figure 1](image)

**Transmission Restoration Program and Project Background**

OG&E’s restoration program encompasses both aerial and ground line inspections. OG&E’s vegetation management group flies each line every year and can assess encroachment issues, as well as, significant aerial problems or breaks. Osmose is utilized to inspect and treat ground line issues and initially classify each pole’s level. Finally, CEC is tasked with assessing poles top to bottom. CEC reviews Osmose inspections and visually inspects the entire structure in a more thorough process, looking at ground line, hardware issues, sounding poles, and often using a UAV to inspect aerial damage at a closer depth. CEC’s field assessment of each support structure includes the analysis of each structure and recommendations for repair, reinforcement, or replacement. CEC, with OG&E’s overview, determines the best solution for rehabilitation and updates drawings, generates a material list, and provides a total cost estimate for each transmission line inspected. OG&E’s cyclical program is expected to reach each line in their system every 10 years. Each team, both Osmose and CEC, ideally inspects the line chosen in the same calendar year.
As part of OG&E’s restoration program, when issues are found, they are classified as either Level 1, 2, 3, or break-fix. Different intensities of deterioration determine the severity of levels that are assigned to each pole. Poles deemed level 3 are in good shape and expected to last the remainder of life until the next inspection. Level 2 poles show deterioration but are not deemed a high priority and are placed on a watch list. Level 1 poles show significant damage with a high priority of replacement. Usually these are replaced within the year. Break-Fix poles show extreme deterioration with immediate threat of danger. It is OG&E’s philosophy to immediately replace these poles.

In this case, because washout was threatening to eliminate the location of the structure, OG&E decided to reroute the line instead of classifying it as Level 1 or Break-Fix. They continued utilizing the services of CEC to route the line and design the preferred alternative. Together, they came up with five alternative routes as depicted in Figure 2 below. Each of the routes veered away from the existing Right-of-Way (ROW) because the river crossing there would require a very long span. The alternatives considered could all be built with standard structures and wires making future maintenance or storm recovery efforts less difficult.

After some discussion, routes 2 and 4 were eliminated because some of the structures would be inaccessible by truck. Therefore, CEC was tasked with estimating routes 1, 3 and 5. The estimates all came back very similar in cost. Even though Route 1 was slightly more expensive than the others, it was chosen as the preferred alternative. It intruded the least into the farmable land South of the river. CEC’s team began the work of design on the preferred route while OG&E began the ROW acquisition process. If you’ve ever been involved in a transmission project, you’re probably aware that the easiest way to derail it is difficulties acquiring ROW. Despite everyone’s best efforts, that was the case with this reroute.
It was at this point that OG&E was forced to make the tough call of whether to continue to fight for new ROW or abandon the completed reroute design and rebuild along the existing ROW. They decided to go with a long span design on the original ROW. So, CEC was sent back to the drawing board and began working on the long span design. In order to stay at least 200’ away from the ever-changing riverbank, the span ended up being 2551’ long.

In order to design a span of that length with standard Aluminum Conductor Steel Reinforced (ACSR), in this case 477 kcmil ACSR 26/7 “Hawk”, the structures would have to be 215’ tall. Structures over 200’ tall require FAA permitting, painting, and lighting (AC 70/7460-1L, 2015, pg. 2-1). As a rule, OG&E likes to use standard materials whenever possible. However, considering the upfront and ongoing maintenance costs of the FAA requirements, we at CEC decided to propose using a special conductor to reduce the height below FAA guidelines.

There are many different types of conductors to consider for low sag applications. We considered the following: All Aluminum Alloy Conductor (AAAC), Aluminum Conductor Composite Core (ACCC), Aluminum Conductor Composite Reinforced (ACCR), Aluminum Conductor Steel Supported (ACSS) conductors with HS-285 cores, Alumoweld, and finally Aluminum Alloy Conductor Steel Reinforced (AACSR). See Figure 3 below for a comparison of the sags of each conductor type at both 212° F and 32° F with ½” ice.

Each type of conductor has its niche, and all are useful in certain circumstances. They all have their relative strengths and weaknesses. AAAC has great electrical characteristics, ampacity and resistivity, compared to many of the others. However, it’s strength to weight ratio isn’t as good, causing it to sag more and making it less than ideal for this project. ACCC wires have a composite core. They offer very low sag even at extreme temperatures, but this project’s constraints didn’t call for higher temperatures. What this project did require was heavy ice and wind loading per Rule 250B of the National Electrical Safety Code (NESC®, 2017, pg. 203). Composite cores are great thermally, so high temperatures barely affect them, but mechanical loading such as ice still affects them similarly to standard ACSR conductors. See Figure 3 – the ACCC sags 47 feet more with ½” ice than it does at 212° F. ACCR conductors have composite reinforcement in their core strands. While their sags are better than standard ACSR conductors, they aren’t quite what we were looking for on this project.

ACSS with HS-285 high strength steel core has similar electrical characteristics to standard ACSR, but the high strength steel core allows you to pull it tighter and gives you less sag both under thermal and mechanical loading. However, its strength to weight ratio isn’t quite as good as AACSR so we didn’t choose it. Alumoweld wires offer excellent strength to weight ratios, providing very low sags. However, their electrical properties are poor compared to aluminum conductors. AFL says that Alumoweld has one-third the conductivity of an equally sized Alloy 1350 (EC grade) aluminum wire (Alumoweld® Aluminum-Clad Steel ACSR/AW Core Wire, 2019). Alumoweld should only be used as a conductor in situations that demand the lowest possible sag.
### Legend for Figure 3 with Sags

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<thead>
<tr>
<th>Line Style</th>
<th>Conductor</th>
<th>Sag (ft.)</th>
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<tr>
<td></td>
<td>Hawk ACSR at 212° F</td>
<td>179.6</td>
</tr>
<tr>
<td></td>
<td>Hawk ACSR at 32° F, 1/2” Ice</td>
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<td>Hawk AACSR at 212° F</td>
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<td></td>
<td>Hawk AACSR at 32° F, 1/2” Ice</td>
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<td></td>
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<td>Hawk ACC at 212° F</td>
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<td></td>
<td>Darien AAAC at 32° F, 1/2” Ice</td>
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</table>

**Figure 3**
Solution
The final conductor type we considered and the one that we chose was AACSR. We call it the forgotten high strength, low sag conductor because it’s not very common. It is hard to find information about it online. At the time of the Fixico to Kolache project, we couldn’t find any .wir files for it for use in PLS-CADD™ design software. It took some research and a few calls to the manufacturer to create a .wir file with the proper stress strain coefficients and properties to use in PLS-CADD™.

It’s surprising that AACSR isn’t more popular in the industry or more readily available. It is the same as ACSR except that a higher strength aluminum alloy is used instead of the standard aluminum. In the case of our 477 kcmil 26/7 “Hawk” AACSR, this correlated to a 44% increase in strength. The weight remains almost identical, but the strength is greatly increased. The increase in strength directly correlates to a decrease in sag when sagged to the same percentage of Rated Breaking Strength (RBS) as the corresponding ACSR. Since the lower sag in this conductor is strength based it works for both higher temperatures and mechanical loadings. Standard strain clamps, suspension clamps, armor rods, and other materials can be used with it if their strength rating matches the strength of the conductor. No special handling requirements or specialized construction techniques are necessary. Instead of 215’ structures for ACSR, we were able to use 155’ and 165’ structures to span the river and avoid the 200’ height limit imposed by the FAA.

There are also some things to watch out for when thinking of implementing an AACSR solution. First, it isn’t designed for extreme high temperatures. In fact, the whole point of AACSR is to count on extra strength from the Aluminum Alloy strands so it isn’t wise to heat it to the point that hot spots in the wire could anneal. The Fixico to Kolache project only required a maximum operating temperature of 212°F so that wasn’t an issue. Also, the ampacity of the aluminum alloy in AACSR is less than the ampacity of the alloy used in ACSR. Hawk AACSR conductor has about 6% less ampacity than Hawk ACSR. OG&E’s transmission planning department became aware of this during the design phase of this project. We could have chosen a larger diameter AACSR or one with trapezoidal strands to get more ampacity but they determined that there were other factors in their system that limited the ampacity of the line more than the stretch of AACSR so they allowed us to continue with Hawk AACSR.

Conclusion
When confronted with a problem like the Fixico to Kolache river crossing, consider AACSR conductor among the viable options. It has an excellent strength to weight ratio, so it has much less sag than many of the alternatives. Since its low sag is based on mechanical strength, not thermal properties, it behaves very well under ice loading so it can be utilized in areas, like Oklahoma, that are prone to heavy ice. It doesn’t require any special tools or construction techniques to install, lowering installed cost.

For long span situations such as the Fixico to Kolache crossing of the Canadian River, the reduction in sag might be enough to avoid other costly measures such as FAA painting and lighting. In this instance, AACSR proved to be a cost effective, timely solution for OG&E to eliminate future washout problems on their line.
Aerial View of the Finished Crossing
Reference List

