Super-Span Structures

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INTRODUCTION

For almost a century, county officials have depended on the durability and economy of corrugated metal culverts for highway drainage applications. Since 1931, county engineers have been designing drainage structures with structural plate pipe. Now a new development permits previously unknown clear-span openings of corrugated steel structures for bridges, underpasses and waterways.

BACKGROUND ON DEVELOPMENT

Up until 1960, avalanches were a periodic pain in the neck to maintenance officials of the Trans-Canada Highway. At a point in Rogers Pass near Lake Louise, annual avalanches sent tons of snow and rock cascading down the mountain onto the highway below. Often the road was closed for days while crews worked around the clock to clear the way.

In 1960, Canadian highway officials installed a snowshed at this location to take the brunt of these avalanches and direct slides over the road. But this was not a conventional snowshed.

Developed by Chris Fisher, an Armco engineer, the design called for a 30-foot-span structural plate arch of relatively light gage steel. Stability was accomplished by utilizing retaining wall spreader arch principles with the thrust transferred through a series of tension straps, attached to the structure and to embedded anchors. Revolutionary at that time, the concept worked. That structure is still doing its job today. But of more far-reaching importance, the Rogers Pass snowshed gave birth to a new product, a structure design called by Armco, “Super-Span.” Super-Span has opened up the application for the culvert-type bridge to clear spans of 50 feet and more. Figures 1-5 show five steps in the erection of a Super-Span structure.

To date, more than 300 Super-Span structures have been erected in the United States and Canada with some spans up to 50 feet and clear
Figure 1. Excavation and Bedding. Excavation for this Armco Super-Span structure encompasses a large enough area to facilitate use of back-filling and compaction equipment. Stone ballast was placed for drainage and leveling. Here, a pre-assembled invert section is being lowered into position.

Figure 2. Erection. This job followed normal procedure in that bottom plates were assembled first. Cover on invert stabilizes structure and permits traffic during erection of side plates. Some crews use movable scaffolding to facilitate erection of center (top) plates.
Figure 3. Backfill. Super-Span allows large equipment—such as this sheep's-foot—to work close to the pipe.

Figure 4. Thrust Beams. On this installation, backfill was brought to the bottom level of the thrust beam placement area, then forms were built and concrete was poured in standard fashion. Longitudinal and L-shaped reinforcing bars, which are attached to the Super-Span with hook bars, uniformly distribute forces over a wide area. Backfill will be completed after the concrete has cured.
openings of approximately 1000 square feet. They serve as vehicular and railroad underpasses, stream enclosures, culverts, bridge replacements and storm drains. Major reasons for this usage record are esthetic design, quick installation and reasonable costs.

DISCUSSION

A Super-Span structure is inherently a major engineering combination of steel and soil.

We can consider Super-Span as two retaining walls held apart at the top by a spreader arch. Using this concept helps to explain how Super-Span design handles backfilling loads and solves buckling problems—two key factors in limitations of size for conventional corrugated structures. First, consider backfilling forces:

Large circular shapes and conventional vertically ellipsed pipe have relatively high sidewalls with little effective horizontal thrust at the top. Therefore, for sizes over 20 feet in span, these walls are relatively weak during backfilling. Super-Span has two solutions for this problem.

With its unique wide-span horizontal shape, Super-Span requires a side retaining wall of about half the height and less than half the radius of the round pipe. This results in a much more stable
wall to resist backfill forces. In addition, the restraining force of the top arch is almost doubled.

Super-Span's pear shape, designed for high narrow clearances, slopes each sidewall toward the natural soil repose and soil pressures act at an acute angle to the walls. This is opposed to conventional vertically ellipsed pipe where these pressures act at nearly 90-degree angles to the upper half of the sidewall.

Two solutions to the same problem, each tailored to the particular shape involved. But in both cases, the high horizontal thrust to the top of the Super-Span structures results in stable sidewalls and safe, efficient backfilling.

Next consider buckling of the top arch:
At the approximate ten and two o'clock positions on the structure, the slope and the flexibility of the structure wall combine to make good soil compaction with economical equipment virtually impossible on these size of structures. Yet this area is the most critical one to the performance of the top spreader arch of the Super-Span. Without its abutment firmly fixed, the relatively flat top arch would be subject to buckling at modest stress levels.
Concrete thrust beams solve this problem by providing an effective vertical wall to compact against. The thrust beam thus fixes the top arch and at the same time reinforces it at its critical point. Other numerous spinoff benefits have resulted, such as distribution of concentrated loads and bridging soft spots.

SUMMARY
Thus, Super-Span is a combination of soil, shapes and thrust beams—all working together to provide structures that can be designed and installed within recognized critical buckling stresses, beam strengths and flexibility factors. And, there is nothing speculative about these structures. They have provided solid solutions to several hundred small-span bridge problems.

These structures are expected to have wide application in county bridge programs. County engineers will now be able to utilize the familiar advantages of steel culverts in new and old bridge problems. These advantages are perhaps most evident in the bridge replacement requirements facing so many counties: Simplified design demands, short construction period, low cost and attractive appearance.