DO ENGINEERING NOTE #3740.540-EN-116

RESULTS FROM THE DO CABLE BRIDGE TESTS

The DØ cable bridge plus mockup MCH tower has been successfully tested with 10 bundle (10" deep) stacks of spectra strip (typical of 25tp muon control and 25tp calorimeter BLS cables) and standard Amphenol, 4 coax wide (solid center conductor + drain wire) ribbons of PVC coax cable (typical of CT shaper and calorimeter trigger cables). The first three articulation cycles (folded up/completely flat) were made on 9/23/87. An additional four cycles under identical conditions were made on 9/25/87. Then slack (ripple) length was added to upper bundles of coax in the base of the mockup tower and another three cycles were made.

The fundamental, important conclusions under the two conditions were:

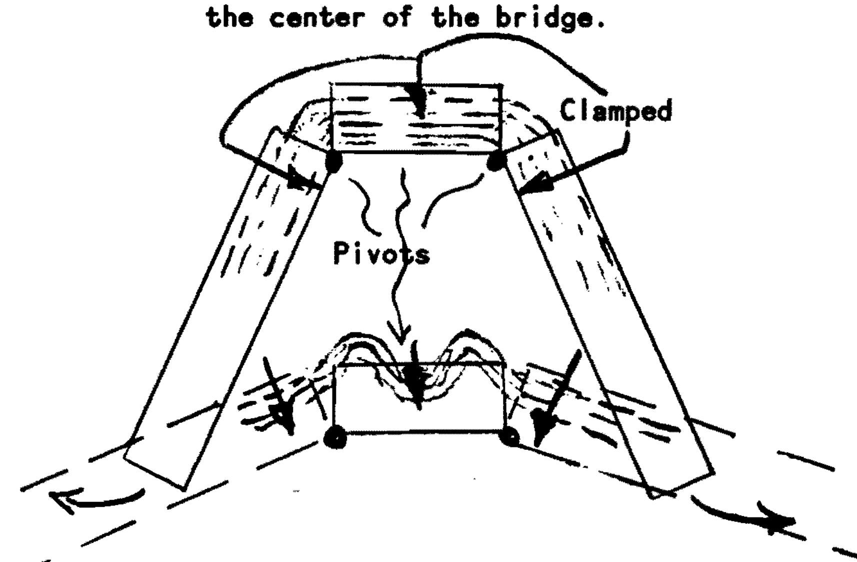
1) Cable motion is repeatable when properly clamped.
2) No cable/bundle is subject to any significant tension or compression forces when installed with the bridge up.
3) The stack moves freely in the tower base slip joint of the bridge when properly installed in the pulled apart configuration.
4) Overlay double folding of the cable bundles in the center section repeats in a natural way with reasonable radii on the bottom bundles and with essentially no resulting compressive forces. All bundles in the humps are "free" enough to be moved by hand.. All but the bottom few bundles are entirely "free" in the these folds. (See figures 5 & 6).

5) The upper bundles tend to wander sideways in the folds so rows of bundles must be separated in fold areas to prevent intertwining.

6) Bagging of the bundles improves bundle to bundle slippage and confines the individual cables in a bundle quite satisfactory. It especially allows the differential motion of cables in a bundle around fixed turns in installation and in articulation.

The success of these tests indicate the following cable installation requirements:

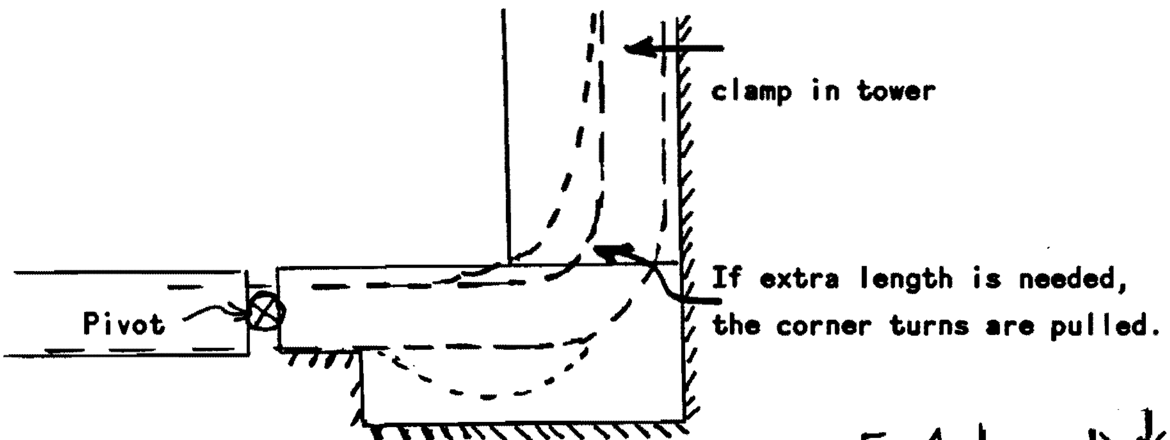
A) Install the cables on the bridge when it is <u>fully</u> <u>up</u>. This insures that the cables will not tighten in the bridge. Trying to install the cables over an "artificial hill" in the middle of the bridge when it is down could misfit the bundle overlay at the center joints. The shape of the double humps are determined somewhat by the bundle motion relative to the nearest clamp (tight) from either side. The pivots are on the bottom in the center of the bridge.



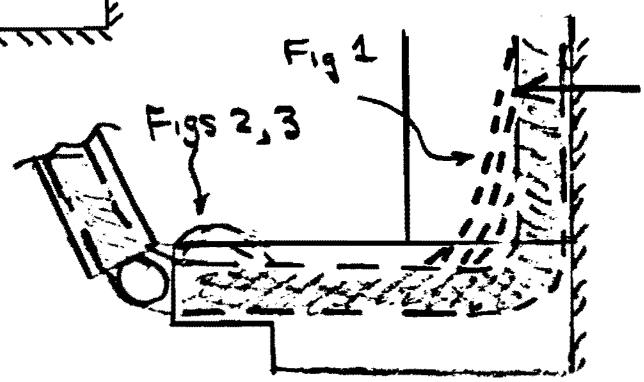
The cable bundles must be clamped tight on each bridge section to guarantee repeatable motion to <u>all</u> joints (ends).

Double hump can be assymetric according to clamp position, bundle tightness from each side.

At the ends of the bridge, the pivots are in the vertical center of the stack. Cables below the pivots are in their maximum arc length configurations for the bridge folded up. Again for bridge down installation, it would be cumbersome to install droop in these bottom cables in the MCH tower base to insure that they will not tighten in the bridge foldup. RATHER it is better to install a fold (lump loop) in the upper bundles of a stack to supply extra arc length when the bridge comes down. If there is error here, then the bottom (vertical) turn of bundles up the MCH vertical tower can be used to supply any more length.

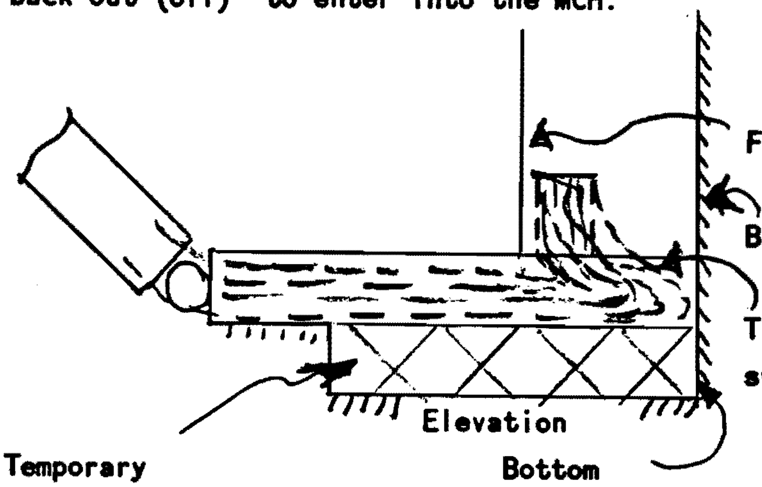


TEST 1: We initially installed a 10" stack with top and bottom bundles flat and straight as follows:



In articulation, the upper (inner) bundles were pulled in to make up arc length for the bridge to come down. On repeated lowering and raising of the bridge, the pulled in length tends to form a loop (ripple at the bottom of the tower which subsequently supplies the extra arc length as needed. This created a stable stiuation. Figure 1 indicates the bundle pull in. Figures 2, 3 indicate the up-down stable bundle configurations.

On the first floor of the MCH, the cables are bound (turn) just at the top level of the cable bridge. Here, extra length can be provided as a safety by running the cables to the back of the vertical duct then sweeping back out (off) to enter into the MCH.

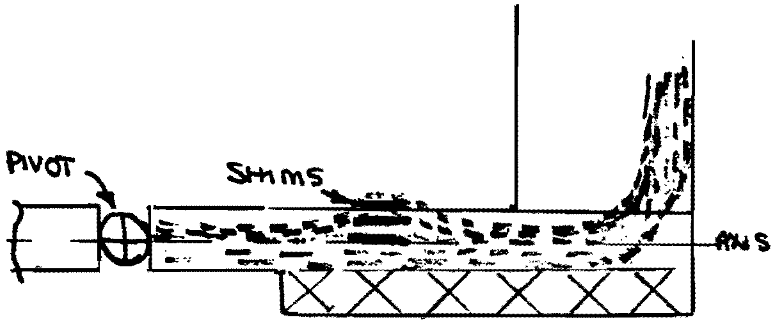


TEST 2:

Subsequently, we created a ripple in the upper bundles at the tower base and regathered the vertical cables. Now the vertical bundles (above the turn) were not pulled during articulation of the bridge. All the cable motion was taken up in the ripple at the base of the tower.

B) Install bottom bundles (below end pivots) in a flat (max. length) arc position on temporary shims in the MCH tower base pits. When the bridge is lowered, the lower bundles of a stack will drop to the bottom of the cable ducts (pits). Going up the stack, each lower bundle will droop less. With a cable bundle in the real MCH tower base, we determined that about one foot of arc length difference can be absorbed in the recess of the ducts in the tower.

The upper bundles (above the end pivots) should be installed in the base of the MCH tower with a progressively increasing ripple. This is to be accomplished by shimming the bundles in installation.



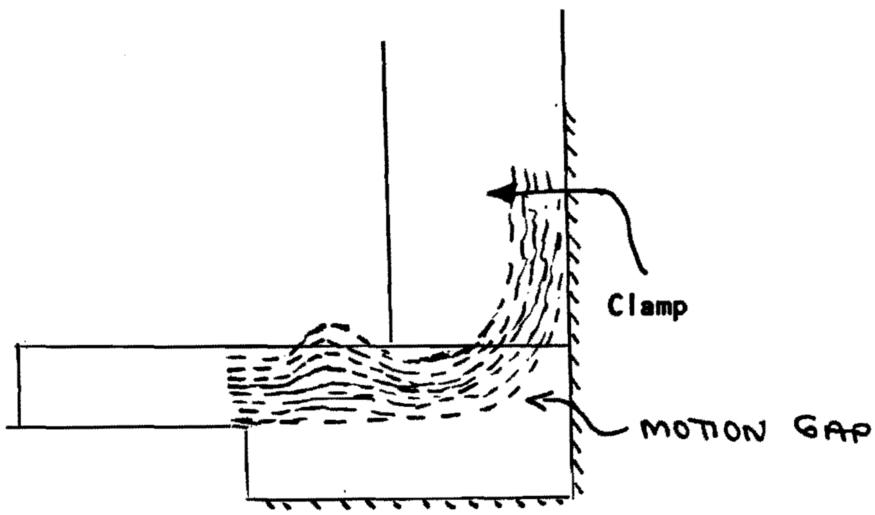
Filling the bridge ducts may require that MCH tower access doors #101, 201, 301 be modified to include a hump-rather than being flat. Such modification can be made at DØ with a heliarc welding machine and copper sheet. When the bridge is lowered, the upper bundles will simply unfold and pull flat; or be slightly levitated. This configuration unpacks the stack but requires smooth sliding which is facilitated by bagging the bundles. We can also add Mylar between bundles here.

C) In installing cable bundles, it be clear that the stacks need support in the joints because they tend to collapse. The required solution is to provide a flexible skin under the cables at the joints. Hard temper brass sheet (22ga) were formed over the joint gaps and function as a support and guide. Coated spring steel sheets would be better. The MCH tower-bridge joint may require a spring sheet guide over the top of the cable stacks to prevent cable rippling in the joint (e.g. fig. 4).

D) In the testing, it became clear that cable stacks must be separated with thin walls at the joints. This prevents any interleaving of loosened bundles from stack to stack. In particular, the walls must extend across the whole center section to isolate the double hump folds as seen in figs. 5 and 6.

E) Repeatability of the double humps and cable rippling at joints require good clamping on the fixed bridge sections. A clamp across the center of the cable stacks at the very center of the bridge is appropriate to symmetrize the double humps.

F) Cables must be installed with the bridge six inches <u>out</u> (apart) from the tower in the slip joint. In initial installation, the bridge must be blocked. This insures that the cable bundles need only shorten between the joint and the vertical tower due to slip joint motion. To accommodate this motion, the radius of the vertical turn of the lowest cable bundle up the tower must be large. Subsequent bundles are convoluted inside. Then bridge slip joint motion translates into a free push-pull of the stack in the MCH tower base.



G) Because of cable bundle motion in the MCH tower base and the cable dumpster (ramps and floor); bundles in the tower should not be clamped before rising ≃ 6FT and bundles in the platform cable dumpster should only be clamped at their entry from (to) the platform floor at the rear (inside) and sides of the dumpster.

FIG. 1

WALKOUT OF UPPER/INNER BUNDLES WHEN BRIDGE IS DOWN WHEN CABLES HAVE NO RIPPLE SLAC IN TOWER

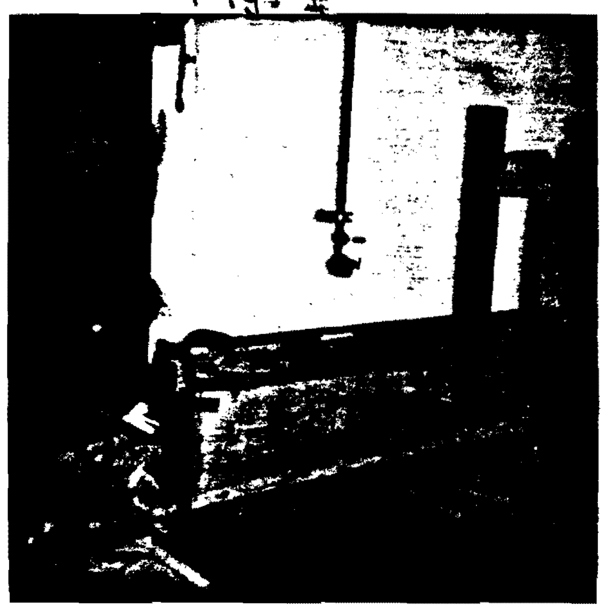
FIG. 2

BRIDGE FLAT AFTER SEVERAL ARTICULATIONS - AT BRIDGE TO MCH JOINT

Fig. 3

BRIDGE UP AFTER SEVERAL ARTICULATIONS (REPEATING DEFORM.) - AT BRIDGE TO MCH JOINT

Fig. 4

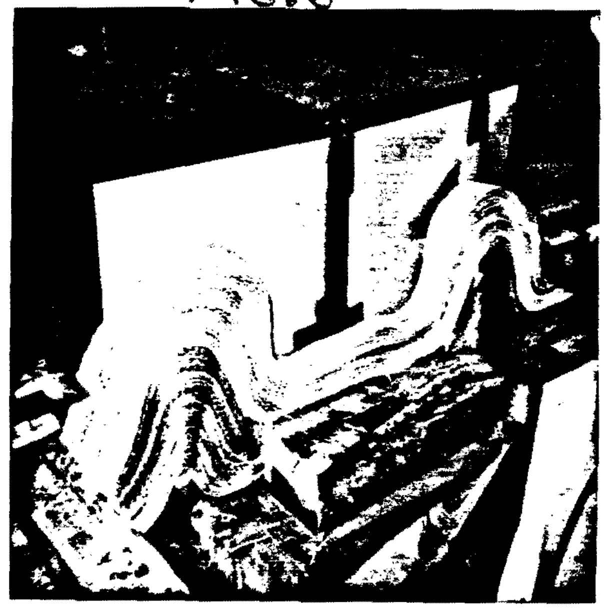


NO WALKOUT OF UPPER/INNER CABLE BUNDLES WHEN BRIDGE IS DOWN AND WHEN THE UPPER CABLES HAVE RIPPLE SLACK IN TOWER

FIG. 5

BRIDGE DOWN DOUBLE FOLDS AT THE CENTER FOR COAX STACK (REPEATABLE—MOST — LAST CYCLE BUNDLES LOOSE IN FOLDS)

FIG. 6

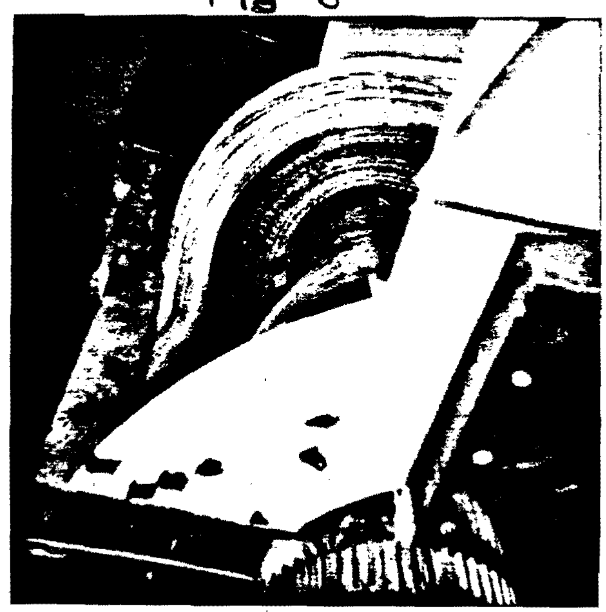


BRIDGE DOWN DOUBLE FOLDS AT THE CENTER (REPEATING) AFTER MANY CYCLES

FIG 7

BRIDGE DOWN DOUBLE FOLDS AT THE CENTER FOR COAX STACK AFTER THE INITIAL THREE CYCLES

FIG 8



BRIDGE "UP" BUNDLE FOLDS AT THE CENTER AFTER ALL TESTING

PROTOTYPE CABLE BRIDGE TESTS

12 LAYERS DEEP OF 1" THICK BUNDLES OF TWISTED PAIR CABLES