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| <u>ITEM 599.1101 10 M</u> | <u>MAINTAINING BALANCE – SB BRIDGE</u> |
| <u>ITEM 599.1102 10 M</u> | <u>BALANCE BLOCKS – SB BRIDGE</u> |
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DESCRIPTION

This work shall consist of establishing the bridge balance by strain gauge method and maintaining balance of the span during the term of this contract. Maintaining balance of the span shall consist of modifying the existing counterweights by the addition or removal of counterweight blocks in the adjustment pockets of the main counterweights. Also included in this work shall be the constant monitoring and adjustment of electrical controls, limit switches and drives, which will be required due to changes in balance and additions and removals of material. Balance Block pay items consist of providing balance blocks in accordance with the Plans and Specifications.

MATERIALS

New balance blocks shall be constructed of the materials shown on the Contract Plans and Specifications. Removed blocks not required shall be stored on the bridge where directed by the Engineer. Cast Iron balance blocks shall be grey cast iron as shown in the Plans. Density shall be approximately 7,144 kilograms per cubic meter (445 pounds per cubic foot). If required, lead for balance blocks shall conform to the provisions of ASTM B 29. Density shall be approximately 11,370 kilograms per cubic meter (710 pounds per cubic foot). Unless otherwise noted, lead balance blocks shall be encapsulated with a high build epoxy coating (Black CLR, 8.0 mils minimum cured thickness) weatherproof pack. Epoxy coating shall be recommended by its manufacturer for this use.

CONSTRUCTION DETAILS

A. General. Balance adjustments are in order to compensate for the replacement or addition/removal of structural steel work, spanlock machinery, and any other items that would cause a change in the present span balance condition. The final balance condition and acceptance criteria of the span shall be as required herein and in the Plans. The contractor is cautioned that several iterative balance tests may be required prior to the acceptance of the final span balance condition. The balance shall be maintained on the spans during all stages of construction. The bridge balance condition shall be established by strain gauge prior to commencement of span rehabilitation work. During all phases of construction, each span shall be properly balanced based upon calculations utilizing actual weights of materials installed or removed. When the work on each leaf of the bridge is completed, bridge balance shall again be checked by strain gauge and the balance shall be adjusted accordingly.

An excessively span heavy imbalance as limited in the Plans shall be permitted on each leaf undergoing construction provided adequate restraints are installed. Final span balance shall take place upon completion of all work on the respective bascule leaf.

A minimum of two strain gauge tests, (one preliminary and one final), consisting of multiple sets of data recordings, per each independent leaf are expected to be performed by the contractor, although more may be required. A strain gauge test shall be understood to consist of obtaining all required strain data and performing all analyses on that data on each of the main rack pinion shafts, or on shafts as close to the rack pinion shafts as practicable. All movement of the blocks is included in this pay item, including the cost of attaining temporary storage space.

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This work shall also include providing, installing and removing temporary weights which may be required to maintain the spans in a balanced condition due to any material additions or removals. The Contractor shall be responsible for the correct amount and placement of temporary weights. Temporary weight calculations shall be submitted to the Engineer for prior approval. New balance blocks required to balance the bridge shall be of the material shown in the Plans and Specifications. All test results shall be submitted to the Engineer. This work shall include all analyses, testing and maintaining the span in a balanced condition. All work shall be in accordance with U.S. Coast Guard requirements.

The Contractor shall retain the services of a New York State licensed Professional Engineer to prepare the calculations for maintaining balance of the span.

The imbalance of each leaf on the Bridge at preliminary and final, and as needed for intermediate balancing, as outlined in the description of work, is to be determined using the dynamic strain gauge procedure under the direction of a Professional Engineer registered in New York State having had prior hands-on experience with imbalance measurements by this method on at least 3 other bascule bridges. Foil strain gauge rosettes shall be attached to the pinion shafts (or other shafts as close to the pinion shafts as feasible) either by adhesive bonding or by spot welding. At each shaft where torque is to be measured, two 90-degree rosettes shall be affixed back-to-back (spaced 180 degrees circumferentially) with the uniaxial grids oriented at 45 degrees to the shaft axis. The two rosettes on each shaft shall be wired in the four-arm Wheatstone Bridge configuration and connected to data acquisition equipment through flexible shielded cables. The data acquisition equipment shall preferably consist of a laptop computer based data logger provided with a four-channel strain gauge module and one channel for measurement of leaf angle. The leaf angle shall be continuously recorded in order to determine varying leaf imbalance moments throughout the raising and lowering of the leaves. The amplified data shall be recorded on a disk at a 20 Hz minimum sample rate with 100x averaging. The data shall be scaled to account for amplification, excitation, strain gauge factor and lead wire resistance.

Because each leaf of the Bridge has its own differential speed reducer and two rack pinions, a total of two shafts per leaf need to be instrumented. The Contractor shall not assume that the differential reducer acts as an exact torque equalizer. This means that a minimum of three channels of information shall be recorded simultaneously, in addition to the time scale.

Data shall be recorded during a minimum of three complete opening and closing cycles. Most likely, additional cycles will be required to set up scales, etc. Before each run, the shafts are to be relieved of residual torque by manually turning a shaft(s) in each span drive until the rack and pinion teeth are not in contact and the data logger zeroed out.

The leaf imbalance moment (M) shall be plotted versus angle of opening (θ) for opening and closing. An average curve $M = WL\cos(\theta+\alpha)$ shall be fitted to the data and plotted giving the probable leaf imbalance moment at any angle of opening. In the foregoing equation:

- M = imbalance moment
- W = total weight of the leaf, including counterweight
- Θ = angle of opening (preferably in degrees)
- L = distance from center of mass to center of trunnion
- α = angle between horizontal line and line passing through center of trunnion and center of mass

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Submit a stand-alone imbalance measurement report including values of WL and α for each leaf, plots with fitted curves and at least one annotated chart for each leaf. Report shall also include list of equipment used with make and model numbers.

The following shall be submitted along with the imbalance measurement report:

1. The name and address of the licensed Engineer to be utilized in this Section.
2. Shop drawings, layout drawings, working drawings, and catalog cut sheets products to be utilized in this Section.
3. Calculations for the span balance:
 - a. Calculations shall be prepared for balance prior to the beginning of work (Preliminary), interim with the work, and after final adjustments to the counterweights are made.
 - b. Preliminary calculations shall account for all existing components to be removed and new components to be installed including allowances for bolts, rivets, welds, paint and normal overruns on plate thickness. The calculations shall account for the longitudinal and transverse location of loads to ensure an even distribution of loads.
 - c. Preliminary calculations shall be formatted such that each removal and installation is in sequential order according to the Contractor's planned schedule.
 - d. The balance calculations summary shall be prepared using a Lotus or Excel spreadsheet. The calculations and results shall be submitted with a compact disk containing the data sets.
 - e. The preliminary balance calculations for the span shall be approved by the Engineer before removal operations can begin. The balance calculations shall be updated on a daily basis as components are removed and added to the span. The updated interim calculations shall be submitted to the Engineer prior to each span opening, upon changing of the temporary restraints and at any other time as directed by the Engineer.
 - f. Reports giving the inventory of balance blocks in each counterweight pocket at each stage shall be submitted to the Engineer.

B. Balance of the Bascule Span.

1. The balanced condition of the spans shall be maintained at all times during the Contract. It shall be checked in the presence of the Engineer at the beginning of the Contract, during construction, periodically throughout the Project as directed by the Engineer and at the end of the Contract.

Maintaining Span Balance During Construction - Based on the actual changes of mass added or removed on the bascule spans, the Contractor shall calculate the placement locations for the existing cast iron or the new lead balance blocks. The balance blocks shall be evenly distributed across the counterweight pockets.

The span shall never be in a counterweight heavy condition. It shall be the Contractor's responsibility to coordinate the structural and spanlock reconstruction, any placement of the temporary steel safety barrier used for Maintenance and Protection of Traffic and span lock work such that the bascule spans are never in an unbalance span heavy condition that may be detrimental in any way to the structure, bridge machinery, electrical control system, traveling public or operating personnel. The acceptable range of final span balance is described in the Plans. The span under construction shall be permitted a span heavy imbalance moment not to exceed that noted in the Plans. Adjustment at the beginning of the contract may be required.

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The Contractor shall perform balance calculations as hereinafter specified. The balance calculations shall be performed by a Professional Engineer licensed in the State of New York. The calculations shall account for the detailed mass of all materials removed and added as part of this project and their location from the center of the trunnion. The mass shall be extremely accurate and account for all material, machinery, electrical equipment, fill plates, gross weight of bolt heads, washers and nuts and any other components either removed or replaced as part of this project including minor machinery components such as grease fittings, covers, etc.

Calculations shall be submitted on spreadsheets showing the material call out, weight, moment arms in the horizontal and vertical directions and the resulting horizontal and vertical moments. Mass removed shall be accounted on separate sheets from mass added. A summary balance table shall be developed as shown on the Plans. The summary tables shall show the staging of the balance and the proposed imbalances.

The calculations shall also account for the placement of new blocks, and repositioning of existing balance blocks. Note that lead blocks and cast iron blocks are both used on this bridge. A narrative shall be included with the outline of the proposed construction staging, the duration of the imbalance and all other aspects of the work. This information shall be coordinated with the Contractor's scheduling requirements and shall be submitted to the Engineer for approval. The mass for new work shall be developed on the shop drawings for each component. The calculations and spreadsheet shall be updated daily by the Contractor throughout construction and be submitted to the Engineer daily.

2. After the completion of all construction requirements for the Bascule Leaf, the final balance of the span shall be as required in the Plans and as approved by the Engineer.
3. Test operations to check the balance of the span will be permitted only at specified times as directed by the Engineer (if bridge closure to vehicular traffic is not permitted).

C. Span Balance Condition. The Contractor shall perform a survey of the number of balance blocks, type and weight of blocks in the counterweight and those which are stored and available as spares before proceeding with preparing a scheme for maintaining the balance. The Contractor shall provide balance blocks as required. All balancing and checking of the span and counterweights shall be performed by qualified personnel. All balancing of the span shall be approved by the Engineer.

D. Interim Span Balance. During construction and based on interim balance calculations, the Contractor shall remove, replace or install the balance blocks in the pockets as necessary so that the span is always maintained within the balance condition, specified herein. Dead loads of known weight may be positioned on the unused portion of span as required, to offset the weight of removed components from the span subject to the approval of the Engineer. Calculations prepared by the licensed Engineer shall be submitted by the Contractor verifying the adequacy of the structural members supporting the additional dead loads.

E. Supplemental Balance Tests. The Contractor may also need to perform additional strain gauge tests in excess of the 8 minimum number of tests if required by his sequence of operations or if directed by the Engineer. No additional payment will be made for these tests in excess of the minimum.

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F. Basis of Acceptance. All fabrication of Structural Steel shall follow all of the requirements of the New York State Steel Construction Manual (SCM). In addition, all shop drawings submitted shall follow all guidelines given in the SCM. No installation or rehabilitation work may take place until the shop drawings and procedures are approved by the Engineer.

METHOD OF MEASUREMENT

The work for Maintaining Balance will be measured for payment on a lump sum basis for each bridge.

The work for Balance Blocks will be measured for payment by the number of kilograms of block satisfactorily furnished. The cost for all coatings shall be included in the unit weight cost for the material.

Weight will be calculated for coated lead balance blocks as 11370 kilograms per cubic meter (710 pounds per cubic foot). Weight for coated steel balance blocks will be calculated as 7,870 kilograms per cubic meter (490 pounds per cubic foot). Each side of a representative sample of blocks will be measured to the nearest 6 mm (1/4") for the purpose of volume calculation. The representative sample will consist of a minimum sample size of 10 blocks per lot and the values will be averaged. Alternatively, a sample size of 15 blocks per lot will be individually weighed and weights averaged. This average value will be used as the weight per block used.

BASIS OF PAYMENT

A. Maintaining Balance. The lump sum price bid shall include the cost of furnishing all labor, materials, and equipment, and Professional Engineering Services necessary to satisfactorily complete the work, except for the material cost of providing new Balance Blocks. This lump sum will be paid in the following installments, with each payment subject to approval of the balance by the Engineer:

35% of the lump sum will be paid upon successful completion of the preliminary set of strain gage tests and associated weight adjustments for both leaves, subject to the Engineer's approval;

30 % of the lump sum will be paid upon successful completion of the bridge balancing consisting of all interim balance calculations and associated weight adjustments, subject to the Engineer's approval;

35% of the fixed price lump sum will be paid upon successful completion of the final set of strain gage tests and associated weight adjustments for both leaves, subject to the Engineer's approval.

B. Balance Blocks. The per kilogram price bid shall include the cost of furnishing all materials, labor and equipment necessary to satisfactorily furnish new Balance Blocks to the work site, as directed by the Engineer. Balance blocks will be on an "if and where directed" basis. However, the minimum number of blocks to be supplied shall be that shown in the Plans. Payment for the relocation of existing or new Balance Blocks on the bridge shall be paid for under the Maintaining Balance item.