ITEM 599.03  10 M – BALANCE BLOCKS
ITEM 599.1110  10 M – BASCULE SPAN BALANCE

DESCRIPTION

Bascule Span Balance

This work shall include balancing and balance testing the movable span to ensure compliance with the design criteria listed on the Plans and elsewhere herein for the bascule span leaves. Balance testing shall be performed using the dynamic strain gage procedure as described herein. This item includes the calculation and documentation of the span balance procedure and methods. All work required to complete the span balance, including placing, removing and adjusting the location of the balance blocks within the counterweight and counterweight pockets, is included in this item.

Balance Blocks

This work shall consist of fabricating and transporting to the site cast iron balance blocks as shown on the Contract Plans. This work also includes storing additional blocks for future counterweight adjustment at a location on the bascule pier as directed by the Engineer.

MATERIALS

New balance blocks shall be constructed of cast iron. Block dimensions and quantity furnished shall be as shown on the Contract Plans. Cast iron balance blocks shall conform to the provisions of ASTM A48M. If required, lead may be used instead of cast iron with the approval of the Engineer. Lead for balance blocks, if required, shall conform to the provisions of ASTM B 29. Density shall be 11370 kilograms per cubic meter (710 pounds per cubic foot). All lead balance blocks shall be encapsulated with a high build epoxy coating (Black CLR, 200 micrometer (8.0 mils) minimum cured thickness) weatherproof pack. Epoxy coating shall be recommended by its manufacturer for this use.

CONSTRUCTION DETAILS

Calculation Of Leaf Balance During Construction.

Balance calculations shall be prepared prior to fabrication and construction based on approved shop drawings and material tests, and shall be submitted to the Engineer for review and approval.

The Contractor shall measure the imbalance moment and determine the location of the leaf center of gravity a minimum of twice:

(1) Initial - After leaf construction is completed to determine the balance condition and to determine the required adjustments. Prior to performing initial balance testing, the Contractor shall submit balance calculations and summary tables to the Engineer for review. The maximum calculated span imbalance as shown on the Contract Plans shall not be exceeded at any leaf position.

Subsequent to initial balance testing, the Contractor shall compute the amount and location of weight adjustments required to achieve the final imbalance specified in the Plans and as described herein and submit the computations to the Engineer for review. After the Engineer's review, the Contractor shall make the approved adjustments.

(2) Final - After balance block adjustments, to determine if the revised imbalance is within the limits specified on the Plans and as described herein. Leaf operation for final balance testing shall be
performed with the span drive machinery. If the second balance testing indicates that the revised imbalance is not within acceptable limits, further balance block adjustments and imbalance measurements are to be performed until the criteria specified on the Plans and herein are met.

A Professional Engineer licensed in the State of New York shall perform the balance calculations. The quantity and location of balance material required within the counterweight and counterweight pockets, including concrete, balance plates, and balance blocks, based on the specified balance requirements and the weight and center of gravity of each bascule leaf shall be computed. These calculations shall be based on weights of approved shop details and material tests for the actual material on each leaf, including the counterweight box. The calculated weight shall be extremely accurate and account for all material, weld fillets, bolt heads, washers, nuts, paint, normal overruns on plate thickness, etc. The balance calculations shall incorporate the distributions of leaf weight in the vertical, horizontal, and transverse directions.

Summary balance tables shall be developed and shown on the shop drawings. The format of these tables shall be in accordance with the balance tables shown in the Plans. Summary tables shall be developed for all phases of the balance and the proposed imbalances. Temporary balance material, if used, shall be accounted for in the summary tables. All summary tables and back-up materials shall be submitted for review. A narrative shall be included with the outline of the proposed phasing, the duration of the imbalance condition, and all other aspects of the work in accordance with the approved construction schedule. This information shall be coordinated with the Contractor's scheduling requirements and shall be submitted to the Engineer for review. Weights for new work shall be developed on the shop drawings for each component. The balance calculations and summary tables shall be updated by the Contractor throughout construction and be submitted to the Engineer periodically as required to meet the requirements in these Special Specifications and in the Plans.

It shall be the Contractor's responsibility to provide temporary bracing and supports and/or temporary balance material as required to stabilize the movable span during construction. It shall be the Contractor's responsibility to coordinate work such that the bascule leaves are never in an unbalance condition that may be detrimental in any way to the structure, electrical/mechanical components or the safety of construction personnel.

Review of the balance calculations, counterweight details, and quantity and location of balance material does not relieve the Contractor from making such changes in the counterweights and balance material as deemed necessary to balance each leaf. All changes shall be submitted for approval.

**Measurement Of Span Balance.**

The balance of each leaf of the movable span shall be measured using the dynamic strain gauging technique. The Contractor shall furnish and install all equipment, materials, instruments and labor necessary to determine the imbalance by dynamic strain gauging.

The Contractor shall employ the services of an established testing company experienced in dynamic strain gage measurement of movable bridge imbalance, subject to approval of the Engineer. Such experience shall be demonstrated by identifying a minimum of six movable bridges including at least three trunnion bascule bridges for which the company has provided complete and satisfactory dynamic strain gage measurements and reporting. The measurements shall be made under the immediate direction of a Professional Engineer registered in the State of New York who has had hands-on-experience measuring movable span imbalance by the dynamic strain gage procedure.
The testing company shall furnish and install the required strain gages, all cabling and transmission equipment, data acquisition equipment and strip chart recorders and produce fully documented reports detailing the results of the measurements. Acceptable testing companies include:

- SMI Incorporated, Pittstown, NJ
- Teledyne Engineering Services, Waburn, MA
- Stafford Bandlow Engineering, Washington Crossing, PA.

The approved testing company shall submit the following items to the Engineer for approval:

1. Description of experimental procedure including type and method of installation of strain gage rosettes, method of transmission of low level signals, data acquisition equipment and/or strip chart recorders.
2. Layout of span drive machinery showing proposed location of strain gages, amplifiers, cable or radio links, data acquisition equipment and all associated cabling.
3. Details of method of transmission of signals from shafting to data acquisition units.
4. Elementary wiring diagrams of interconnection of strain gages, amplifiers, data acquisition equipment, and strip chart recorders.
5. Sample computations of: shaft torque from measured strains, span imbalance, curve fitting and basis for friction correction.

Two foil resistance strain gage rosettes shall be affixed to each of the main pinion shafts, in accordance with the strain gage manufacturer's installation instructions. They shall be 2-arm 90 degree rosettes mounted such that the grids are oriented at 45 degrees with the shaft axis and the two rosettes shall be affixed "back-to-back", spaced 180 degrees apart circumferentially. The gages shall be connected such that any bending strains in the shafts will be canceled and torsional shearing strains will be measured on each pinion shaft. The areas of the shafts where the gages are to be mounted shall be sufficiently cleaned to remove all contaminants. On each shaft, two rosettes shall be mounted at 180 degrees from each other. The two gages shall be connected such that any direct shear forces in the shafts are neglected and true torsional shear is measured.

The strain gage leads on each shaft shall be connected to a four arm amplifier. Transmission of signals from the gauges to the data acquisition equipment shall be either through cable links or amplified and then through wireless transmitters.

Output leads from each channel of the amplifiers shall be connected to either a computer-based data logger provided with a two-channel strain gage module streaming the amplified data to disk at a minimum 1-kHz sample rate, or a five channel minimum strip chart recorder with at least 250 mm wide chart paper. An inclinometer shall be provided to provide continuous leaf angle to either the datalogging equipment or the strip chart recorder. The chart speed shall be step-wise adjustable and shall include a setting of at least 250 mm per minute. The recorder shall be capable of recording data from at least 4 channels if it is equipped with a dedicated event marker or 5 channels if a channel is used to record events.

The strains in both shafts shall be recorded simultaneously versus span opening angle during opening and closing to a suitable scale. The readings for all shafts shall be recorded at the same strain scale and the chart speed, if a strip chart recorder is used. At least 3 opening/closing runs shall be made, when the wind speed is less than 8 km/hr and the bridge deck is visibly dry. Wind-up torque in the operating machinery shall be released prior to each run as verified by space between the faces of the engaged teeth of main pinion and gears.
The strains induced in the shafts shall be numerically converted to torque by applying fundamental stress-strain relationship calculations for each strain plot for both opening and closing. This data shall be processed to give leaf imbalance (kN-m) versus opening angle, corrected for friction, at each trunnion. From them, plots of total span imbalance shall be prepared.

The Contractor shall submit five copies of a report documenting the results of the initial strain gage measurements. Separate reports are required for each leaf. The reports shall contain the following:

1. Description of experimental procedure and equipment used.
2. Span drive diagram showing location at which strain gages were attached and all applicable gear ratios.
3. Photocopies of a sample original strip chart for one complete run of each of the three sets in the case of strip chart recordings or data and chart files in Excel format if recorded by a data logger. They shall be annotated with strain scales, angle of opening, significant ordinates, etc.
4. Description of relationships and sample calculations for obtaining shaft torque from strains, span imbalance from shaft torque, curve fitting and basis for friction correction.
5. Plots of the following parameters versus degree of opening during each opening/closing run and fitted balance curves corrected for friction:
   a. Total imbalance (kN-meter) for span.
   b. Frictional moment (kN-meter) for span.
6. Tabulation of imbalance moment at seated position for each leaf/run including the average value for each leaf.
7. The location of the leaf center of gravity.

After balance block adjustment, the Contractor shall submit five copies of the final balance report, similar to the initial report.

The reports will be bound between heavy plastic covers. The report shall include an introductory section giving the name of the bridge, the date of the measurements, weather conditions during measurements and any other information requested by the Engineer.

The final imbalance measured by the procedures described herein shall be considered acceptable if:

1. The allowable range of imbalance with the leaf in the seated position and the maximum allowable imbalance throughout the operational travel of each leaf meets the requirements stipulated on the Contract Plans.
2. The location of the final center of gravity for each leaf in the seated position is as shown on the Contract Plans.

METHOD OF MEASUREMENT

"Bascule Span Balance" will be measured on a lump sum basis.

"Balance Blocks" will be measured as the number of kilograms of balance blocks furnished.

BASIS OF PAYMENT
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The quantity and total weight of balance blocks furnished shall be as shown on the Contract Drawings. Additional balance blocks shall be furnished if required to meet the balance criteria specified in the Contract Documents. If, with the Engineer's approval, the Contractor modifies the mass of the bascule leaves solely for the purpose of facilitating his/her operations, there will be no measurement made for additional blocks necessitated to balance such modifications.

The lump sum price bid for "Bascule Span Balance" shall include the cost of all labor, materials and equipment necessary to complete the work in accordance with the Contract Plans and Specifications. The cost of all analyses, testing, and Professional Engineer services shall be included in the lump sum price. The price bid shall include the cost of installing, removing and/or adjusting the location of balance blocks to achieve final balance.

The unit price for “Balance Blocks” shall include the cost of all labor, materials and equipment necessary for fabricating and transporting the blocks to the site. The price bid shall also include storing additional blocks for future counterweight adjustment at a location on the bascule pier as directed by the Engineer.