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APPENDIX 4-6

BRIDGE CROSSING STRUCTURAL ASSESSMENT REPORT



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PROPOSED SESKIN WIND FARM TURBINE DELIVERY ROUTE, COUNTY CARLOW

Bridge Crossing Structural Assessment Report

December 2023



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**DOCUMENT APPROVAL**

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The modified MEXE method determines the carrying capacity of masonry arches in terms of allowable axle weights. This method takes account of the materials, various defects and geometric proportions which affect the strength of the arch.

2 **RIVER DININ BRIDGE (BLACK BRIDGE) CO. CARLOW / KILKENNY - BRIDGE DESCRIPTION**

Dermot Guilfoyle of Jennings O'Donovan & Partners Limited inspected the bridge on the 24th August 2020. The bridge is a large single-span stone arch structure. The arch is 14m wide (springing level) and an arch height of 5.158m with an overall height of 8m to riverbed level. The minimum compression zone/spandrel fill is approximately 0.25m. The parapets are 500mm wide random stone masonry with average height of 1.4m above the road surface.

The undersides of the arches were found to be in relatively good condition but with some localised minor deterioration at some of the joints.

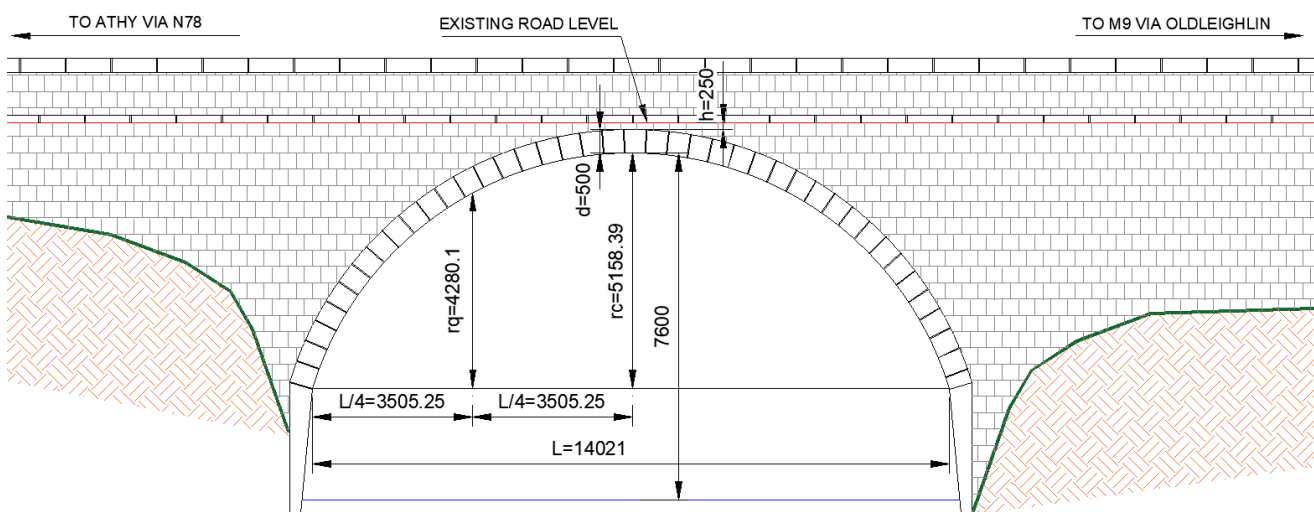


Figure 2 – Bridge Dimensions for MEXE Method Assessment

3 ASSESSMENT BY MEXE METHOD

3.1 Current Condition

Arch dimensions used

- Span $L = 14.021\text{m}$
- Rise $r_c = 5.158\text{m}$
- Rise at quarter points $r_q = 4.28\text{m}$
- Thickness of arch barrel $d = 0.50\text{m}$
- Average depth of fill, $h = 0.25\text{m}$

Provisional Axle Loading (PAL) (BA 3.10)

$$\begin{aligned} \text{PAL} &= [740 \times (d+h)^2] / L^{1.3} && \text{or } 70 \text{ (whichever is less)} \\ &= [740 \times (0.5+0.25)^2] / 14.021^{1.3} && \text{or } 70 \text{ (whichever is less)} \\ &= 13.44 && \text{or } 70 \text{ (whichever is less)} \end{aligned}$$

$$\text{PAL} = 13.44 \text{ tonnes}$$

Modifying factors (NRA Design for Roads and Bridges – Assessment of Masonry Arch Bridges by the Modified MEXE Method):

- Span/rise $= 14.021 / 5.158 = 2.541$
- Span/Rise Factor (F_{sr}) $= 1.00$ (as actual span / rise is less than 4 – figure 3.3)
- Profile Factor (F_p) $= 2.3[(r_c-r_q)/r_c]^{0.6}$
 $= 2.3[(5.158-4.28)/5.158]^{0.6}$
 $= 0.794$
- Material Factor (F_m) $= [(F_b \times d) + (F_f \times h)] / (d + h)$

Where:

- Barrel Factor (F_b) $= 1.0$ (Table 3.1)
- Fill Factor (F_f) $= 0.7$ (Table 3.2)

Therefore:

- Material Factor (F_m) $= [(1.0 \times 0.5) + (0.7 \times 0.25)] / (0.5 + 0.25)$
 $= 0.90$
- Joint Factor (F_j) $= F_w \times F_d \times F_{mo}$

Where:

- Width Factor (F_w) $= 0.9$ (Table 3.3)

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- Mortar Factor (F_{mo}) = 0.9 (Table 3.4)
- Depth Factor (F_d) = 0.9 (Table 3.5)

Therefore:

- Joint Factor (F_j) = $0.9 \times 0.9 \times 0.9$
= 1.0
- Condition factor (F_{cM}) = 0.90 (based on proven capacity and good condition)
- Axle Factors (A_f) = 1.0 (Figure 3.5a) (no axle lift off)

$$\begin{aligned}
 \text{Modified Axle Loading} &= F_{sr} \times F_p \times F_m \times F_j \times F_{cM} \times PAL \\
 &= 1 \times 0.794 \times 0.90 \times 0.729 \times 0.9 \times 13.44 \\
 &= \mathbf{6.3 \text{ tonnes}}
 \end{aligned}$$

It should be noted that this carrying capacity is for the arch alone, and that the capacity of the full bridge is a combination of several other elements including fill materials buttresses and foundations. It should also be noted that this method can return quite variable results as the modifying factors are subjective. In particular the Condition Factor of 0.9 was taken in this instance due to the overall good condition and proven existing traffic capacity.

However, despite the overall good condition for the structure, the arch is not capable of supporting the maximum axial load applied by movement of standard wind farm delivery vehicles, in its current arrangement.

In order to achieve a modified axle loading in excess of 12 tonnes, the average depth of fill above key stone would need to be increased by 200mm, thus providing an overall depth of 450mm over the span of the arch. It is intended that this would be achieved using Concrete/DBM, tapering back into the existing road level either side. See updated calculation below.

3.2 Proposed Increase of Fill Depth (Road Surface) by 200mm

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Arch dimensions used

- Span $L = 14.021\text{m}$
- Rise $r_c = 5.158\text{m}$
- Rise at quarter points $r_q = 4.28\text{m}$
- Thickness of arch barrel $d = 0.50\text{m}$
- Average depth of fill, $h = 0.45\text{m}$

Provisional Axle Loading (PAL) (BA 3.10)

$$\begin{aligned}
 \text{PAL} &= [740 \times (d+h)^2] / L^{1.3} && \text{or } 70 \text{ (whichever is less)} \\
 &= [740 \times (0.5+0.45)^2] / 14.021^{1.3} && \text{or } 70 \text{ (whichever is less)} \\
 &= 20.47 && \text{or } 70 \text{ (whichever is less)}
 \end{aligned}$$

$$\text{PAL} = 21.59 \text{ tonnes}$$

Modifying factors (NRA Design for Roads and Bridges – Assessment of Masonry Arch Bridges by the Modified MEXE Method):

- Span/rise $= 14.021 / 5.518 = 2.541$
- Span/Rise Factor (F_{sr}) $= 1.00$ (as actual span / rise is less than 4 – figure 3.3)
- Profile Factor (F_p) $= 2.3[(r_c-r_q)/r_c]^{0.6}$
 $= 2.3[(5.158-4.28)/5.158]^{0.6}$
 $= 0.794$
- Material Factor (F_m) $= [(F_b \times d) + (F_f \times h)] / (d + h)$

Where:

- Barrel Factor (F_b) $= 1.0$ (Table 3.1)
- Fill Factor (F_f) $= 0.8$ (Table 3.2)

Therefore:

- Material Factor (F_m) $= [(1.0 \times 0.5) + (0.8 \times 0.45)] / (0.5 + 0.45)$
 $= 0.905$
- Joint Factor (F_j) $= F_w \times F_d \times F_{mo}$

Where:

- Width Factor (F_w) $= 1.0$ (Table 3.3)

– Mortar Factor (F_{mo}) = 1.0 (Table 3.4)

– Depth Factor (F_d) = 1.0 (Table 3.5)

Therefore:

– Joint Factor (F_j) = $1.0 \times 1.0 \times 1.0$
= 1.0

– Condition factor (F_{cM}) = 0.90 (based on proven capacity and good condition)

– Axle Factors (A_f) = 1.0 (Figure 3.5a) (no axle lift off)

Modified Axle Loading = $F_{sr} \times F_p \times F_m \times F_j \times F_{cM} \times PAL$
= $1 \times 0.794 \times 0.905 \times 1.0 \times 0.8 \times 21.59$
= **12.4 tonnes**

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