CAPITA SYMONDS

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Ms M Lane
Colton Parish Council
Lilac Cottage
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OurRef: INF/DC/CS/041305

Dear Ms Lane

BOUTHRAY BRIDGE RECONSTRUCTION

Capita Symonds has been commissioned by Cumbria County Council to study options to reinstate a bridge crossing of the unclassified U5082 road over the River Crake at Bouthray Bridge which was severely damaged by the floods in November 2009. The bridge is currently closed on safety grounds.

Bouthray Bridge is a two span masonry arch which has been widened in the past and therefore consists of two abutting twin span slatestone arch structures. Bouthray Bridge is a Grade II listed structure. A large section of the pier of the upstream arch has been scoured/undercut resulting in the collapse of the pier of the upstream arches and the upstream edge of the arches, spandrel and parapet walls. The downstream arch was also scoured and undercut in places but has not collapsed.

An important part of this study involves consultations with the Environment Agency, South Lakeland District Council, Blawith & Subberthwaite Parish Council, Colton Parish Council, the Lake District Special Planning Board and other bodies to obtain their views on the options and to identify any constraints or conditions that are likely to be imposed. The study will lead to the recommendation of a preferred option to the County Council.

We have investigated four options, three of which are illustrated on the enclosed drawings. The fourth option is unlikely to be viable from both a structural and flood risk point of view and therefore has not been illustrated.

There are no private properties in close proximity to the bridge but there is a gate access to a public footpath at the east end of the bridge and a number of field accesses off the approach roads. The approach road on the west side of the bridge is retained by masonry walls and a 20 metre length of the dry stone retaining wall on the south side of the road has collapsed remote from the bridge. Consequently it is proposed that the new structure should occupy roughly the same footprint as the original. The 3.6m carriageway width on the original bridge is rather narrow by modern standards and does not support two-way traffic but is considered to be satisfactory considering the layout and width of the adjacent roads. Land purchase would be required to widen the bridge which could delay the delivery of the project and extend the road closure with its inconvenience to the public.

To avoid regrading the entrances to adjacent public footpaths and fields and possible retaining wall works, the proposed carriageway level on the approaches will be set more or less as existing. The vertical alignment of the carriageway is unlikely to comply with modern standards but, as with the width, it is considered to be satisfactory considering the low speed of vehicles crossing the bridge. Local variations in road levels over the bridge may be required to suit new deck construction depths and cover requirements.

Part of the upstream elevation of the bridge collapsed during the floods. An inspection of the foundations has been carried out by a team of divers. The upstream arch had a slate on end paved invert and although this was intact in the flood span it has partially washed out in the main span. The abutments have survived the floods intact but there is significant scour beneath the foundations at the downstream end of the main span abutment. Therefore if the lower portion of the abutments below arch springing level were to be reused after some modification, to support the bridge deck there would have to be remedial works to repair the undercutting of the abutments and works to prevent future scour such as the provision of a new paved invert for the whole bridge extending upstream and downstream of the bridge. Trial holes will be excavated in the road to expose the back of the abutments to confirm that this is a feasible proposition and to check the interface between the original and widening arches.

The masonry pier between the main span and flood span had a concrete apron and there was a paved invert to both spans of the upstream arch. The upstream end of the pier has collapsed and the upstream cutwater and the upstream portion of the main span apron have been washed out. The invert of the downstream end of the main span side of the pier has scoured undermining the concrete apron.

The loss of the upstream end of the pier has resulted in the partial collapse of the upstream arches supported and the spandrels, parapets and highway above. There has been loss of stone in the pier facing for the full width of the upstream arch in the main span and for half of the width of the upstream arch in the flood span and it is considered highly unlikely that the arch could be repaired safely, economically and without major works in the river.

The original bridge had slate stone masonry parapets, abutments, pier and wing walls. These features will be incorporated into the new bridge. A metal parapet has been rejected for aesthetic reasons.

Bats were noted to be using this bridge during a survey in 1996 and if required bat roosts could be incorporated into the new structure.

Option A - Drawing No. CS41304/ Bouthray Bridge/SK02 (Rebuild Whole arch structure)

This option gives up to 9 % increase in waterway area over the original upstream arches thereby reducing the risk of flooding upstream. Both of the 2 span masonry arch structures would be demolished and replaced with a new 2 span masonry arch structure for the full width of the bridge. This option generally replicates the form of the original bridge so the waterway area will remain roughly the same as before and there would be a slight mitigation of the flood risk. Construction of the pier would involve extensive coffer dam works within the river increasing the construction time significantly and having a greater environmental impact on the watercourse than the single span option. However the precast concrete arch and spandrel wall units would facilitate speedy construction, with no temporary works within the river, once the pier was in place.

Visually a stone faced arch structure is more in keeping with the Lake District although the National Park does contains alternative types of bridge with an appearance sympathetic to the location.

This would be a robust form of construction, although the lower segments of the arches would be very susceptible to hydraulic forces and impact from floating debris in times of flood. The foundations of the abutments and piers would need to be deeper than those of the existing bridge to prevent scour undercutting the bridge and it would be prudent to reinstate the paved invert under the full bridge footprint which will require significant work in the river and temporary diversions of the flow.

To construct the arches in a traditional way using stone masonry would require special skills that may now be difficult to find. Special temporary falsework would be required over or in the river to support the arches during construction, which would be a very lengthy operation when compared

with the alternatives. In view of these constraints this form of arch construction has not been presented as an option.

Option B - Drawing No. CS41304/ Bouthray Bridge/SK03 (replace upstream arch)

This option gives up to 9 % increase in waterway area over the original upstream arches thereby reducing the risk of flooding upstream. The existing twin span upstream arch would be demolished and a new twin arch construction would be built to generally replicate the form of the original upstream arches so the waterway area will remain roughly the same as before but there would be a slight mitigation of the flood risk.

This option would retain the existing downstream masonry arch 2 span structure although significant remedial works would be required to the undercut foundations which would require involve extensive temporary works in the river. The retained downstream arches may also require a concrete saddle to stabilise the retained arches and to tie them in with the new upstream arches.

Construction of the pier of the new upstream arch would involve extensive coffer dam works within the river increasing the construction time significantly and having a greater environmental impact on the watercourse than the single span option. The flood undercut the pier of the existing upstream arch and has undercut the upstream end of the pier of the downstream arch. The upstream arches had a stone on edge paved invert but this was scoured in the main span. As the downstream arch is being retained this will restrict the depth to which the pier foundation of the new upstream arches can be founded and therefore future scour may be a concern. Therefore protection of the invert against scour will be a major concern and will require a paved invert upstream, under and downstream of the bridge which will require significant work in the river and temporary diversions of the flow.

There are steps in line of the soffit at the joint between the existing upstream and downstream arches with the level of the crown of the existing upstream arches being significantly lower than the level of the existing downstream arches. The upstream edge of the retained downstream arches will have historic movements and bulges and may not be perfectly square but this is currently masked by the existing upstream arches. The joint between the retained downstream arches and the new precast arch may vary in line, level and width but as with the existing joint will not be easily visible. There may be some differential movements between the existing and new arch structures due to the variation in stiffness of the arches.

However the precast concrete arch and spandrel wall units would facilitate speedy construction, with no temporary works within the river, once the pier was in place.

The existing masonry parapets are substandard due to their construction and height. The new upstream arch will be constructed to standard with masonry parapets and to higher height than existing (over 400mm higher than existing in places). Therefore for aesthetic and safety reasons the masonry parapet of the retained downstream arch will have to be raised to a matching height.

Visually a stone faced arch structure is more in keeping with the Lake District although the National Park does contains alternative types of bridge with an appearance sympathetic to the location.

This would be a robust form of construction, although the lower segments of the arches would be very susceptible to hydraulic forces and impact from floating debris in times of flood. The limitations on abutment and pier foundation levels of retaining the downstream arches will result in the bridge being more susceptible to scour and will result in more extensive construction and maintenance works for invert scour protection works.

As with Option A to construct the arches in a traditional way using stone masonry would require special skills that may now be difficult to find. Special temporary falsework would be required over or in the river to support the arches during construction, which would be a very lengthy operation

when compared with the alternatives. In view of these constraints this form of arch construction has not been presented as an option.

Option C - Drawing No.CS41304/Bouthray Bridge/SK04 (New precast beam deck)

This option gives up to a 28 % increase in waterway area over the original upstream arches thereby reducing the risk of flooding upstream significantly. The absence of a pier obviates the need for permanent works in the river reducing the construction time significantly. No unconventional or complicated construction techniques that could slow construction are likely to be required.

The design of the bridge is such that temporary works in the river can be limited to work on abutments at the edges of the watercourse. If the existing abutments are retained there will be works to underpin the undercut areas due to scour of the main span abutment but the constraints imposed by fish spawning are less significant during construction of the bridge structure than in Options A & B. However because of the history of scour on this bridge it would be prudent to reinstate the paved invert of the existing upstream arches and extend it through the invert of the full bridge footprint and approaches which will require significant work in the river and temporary diversions of the flow

The design is very conventional using standard bridge beams and is such that temporary works in the river can be avoided. The construction time for this option is likely to be less than that for Options A & B.

The flat soffit design gives the bridge a 'letter box' appearance which might be considered as rather ugly and utilitarian, although the masonry parapets mitigate this to a certain extent. This would be a very robust form of bridge deck construction which should be able to withstand impact from floating debris with little damage and the absence of a pier makes future scour problems less likely.

Option D - Single Span Concrete Arch

For structural reasons the geometry of the arch would be such that the springing level is below the current level, resulting in a waterway area less than that for the original arches. This would be an unacceptable situation from the Environment Agency's point of view so this option can be rejected.

I would be pleased to receive your comments on the above, the County Council has asked me to deliver my options report as soon as possible so that a preferred option can be agreed and designed in time for construction during the Environment Agency access window during this summer. Your early response would be much appreciated.

Yours sincerely

David Cathcart
Bridge Engineer