# Appendix A.7.2

## Menlough Viaduct Constructability Report

## A.7.2 Menlough Viaduct Constructability Report

Galway County Council

# N6 Galway City Ring Road

# Menlough Viaduct Constructability Report

GCRR-4.03-6.1.74-001

Issue 7 | 28 March 2025



Job number 233985

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# Contents

# 1 Introduction

The N6 Galway City Transport Project, hereafter referred to as N6 Galway City Ring Road (GCRR) or proposed N6 GCRR, incorporates the design of a viaduct structure, known as the Menlough Viaduct in the townland of Menlough to the north of Galway city, as shown in **Figure 1.1** below. The viaduct is situated between the River Corrib Bridge to the west and Lackagh Tunnel to the east. The only changes to this report since its inclusion in the 2018 EIAR and 2018 NIS are updates to reflect the changes to the Project described in Chapter 5 of the updated EIAR and Section 2 of the updated NIS. The construction methods for constructing the Menlough Viaduct remain unchanged.

**Figure 1.1: Site Location – Menlough Viaduct**


The proposed viaduct will be elevated over an area of Annex I habitat, namely Limestone pavement and a Turlough to reduce the environmental impacts of the proposed N6 GCRR. It is located in a rural environment and the terrain is undulating with rocky outcrops and local depressions. The Menlough Viaduct is located outside of the Lough Corrib candidate Special Area of Conservation (cSAC) and between 45m and 140m to the north of the cSAC boundary.

Given the environmentally sensitive location of the viaduct, the rural setting and general accessibility to the site, the construction methods are an important aspect to be considered at this stage. This report describes the possible methods utilised to construct the Menlough Viaduct and the measures taken to minimise impacts on the Annex I habitat.

The Menlough Viaduct can be constructed using different methods, and/or a combination of these methods.

Method 1 consists of constructing from ground level using a protective layer system to protect the Limestone pavement; Method 2 consists of constructing using a cantilever type system with limited works taking place on the Limestone pavement itself; and Method 3 consists of prefabricated construction on a span-by-span basis.

For all methods the following constructability constraints apply:

1. Construction of the viaduct foundations will require specific requirements to be satisfied to ensure that there will be no impact to the groundwater body from the construction. Pouring of the cement for foundations will only be undertaken following inspection and approval by a qualified hydrogeologist that no impact will occur. The inspection will require observation of the full depth and extent of the excavation in order to identify if any karst flow paths, such as conduits, are present.
2. If no karst pathways are evident in the excavation, then the hydrogeologist will approve the construction to proceed.
3. If karst pathways are present in the excavation then there is risk that cement could leak into the aquifer, which would have negative impacts on the groundwater body and any supported groundwater dependant terrestrial ecosystems (GWDTE). The groundwater body underlying the Menlough Viaduct is the Lough Corrib Fen 1 (Menlough) GWB which supports GWDTE in the Lough Corrib cSAC European sites. Potential impacts from cement to the groundwater body include restricting or sealing groundwater flow paths or reducing the water quality due to increased turbidity. In order to prevent these potential impacts mitigation measures are detailed in the Construction Environmental Management Plan (CEMP) to ensure that karst can be managed if encountered so that no impact to the groundwater body occurs.
4. The design of the mitigation is detailed in the CEMP and comprises of backfilling the karst to ensure that the feature does not lose its connectivity or flow path within the aquifer and then secondly the feature is sealed from the excavation to ensure that cement will not enter or impact the feature.
5. Based on the regional groundwater levels measured during the ground investigation the construction and excavations are expected to remain above the groundwater table and on this basis no pumping or dewatering is included in the design. If the excavations need to be deeper than expected, then the construction schedule may need to be modified in order to restrict constructing and inspecting the foundations to the groundwater low.
6. No construction works will take place directly within the extents of the Turlough.

Similarly, the necessary headroom at the side road (5.3m) and a desired headroom for bat passage (2.5m) is provided generally over the full length of the bridge, with the exception of the central portion near chainage (Ch.) 10+200 where the headroom reduces to approximately 1.5m due to the local topography. A further localised reduction in headroom occurs in this area at the point of the peaking of the contours which is approximately 100m², with the absolute lowest clearance at the peak contour being 0.75m. At this location no Limestone pavement protection system will be provided as it would not be possible to safely remove the system. No construction works will take place within this zone from the ground level.

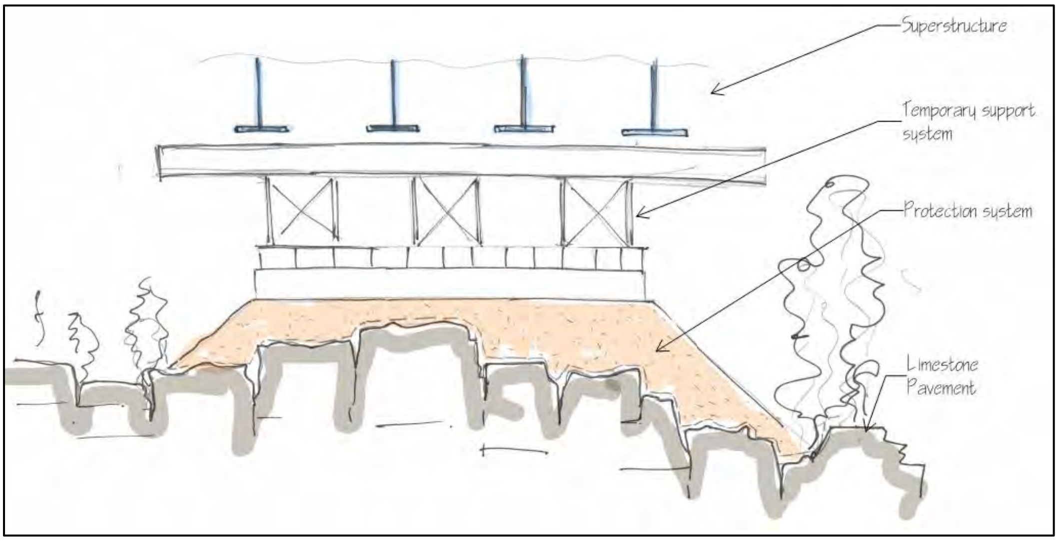
The first and third method, as presented in **Section 2** and **Section 4,** involves protecting the Annex I habitats and then constructing the viaduct off the ground. The measures taken to protect the Limestone pavement and Turlough are also described in **Section 2**. The second methodology detailed in **Section 3** of this report is a balanced cantilever system that would allow some of the viaduct structure to be constructed primarily without any interaction with the ground below. The site preparation and reinstatement works are also outlined in **Section 2**, **3** and **4** for each construction method. A summary of the findings of this report are outlined in **Section 5**.

# 2 Construction Method 1

## 2.1 Introduction

Construction Method 1, will allow construction to be undertaken from ground level, by first installing a protection system over the Limestone pavement, similar to that shown in **Figure 2.1** below, to create a working platform for construction of the viaduct that would not result in a residual impact on the Limestone pavement. In order to protect the surrounding area of Limestone pavement from spillages of sand and gravel from the protection system, the geotextile membrane will envelope the sides of the protection system to contain the various layers.

**Figure 2.1: Temporary construction on Limestone pavement**



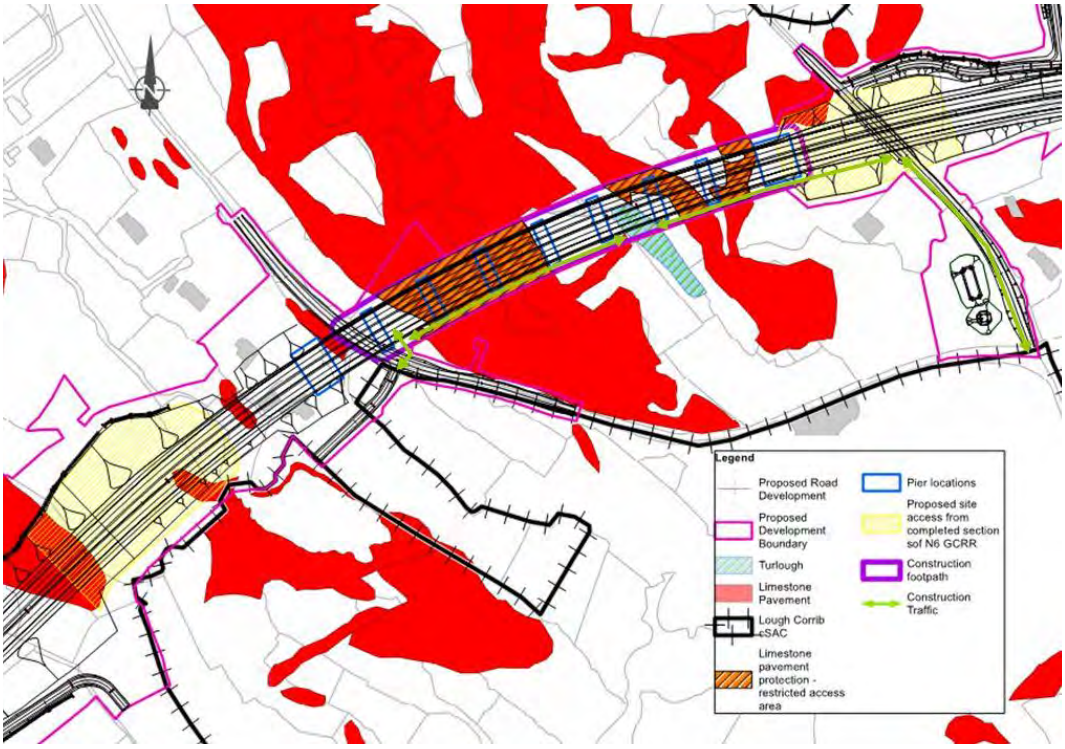

The stages of the construction under this methodology are as follows:

- Stage 1 - Site access and enabling works
- Stage 2 - Construction of the Limestone pavement protection system
- Stage 3 - Viaduct construction
- Stage 4 - Completion of works

## 2.2 Stage 1 - Site access and enabling works

The first stage in the sequence of construction for this section of the proposed N6 GCRR will be to construct the section of the proposed N6 GCRR shown in blue in **Figure 2.2** below as these sections can then be used for site access to construct the viaduct. There will also be limited construction traffic from Bóthar Nua and Sean Bóthar as shown in green in **Figure 2.2**. The access and construction traffic paths have been designed to minimise the impact and interaction with the Annex I habitats. A construction path of approximately 3-5m either side of the bridge deck will be required.

**Figure 2.2: Construction Method 1 Site Access**




The proposed development boundary fencing will be erected to isolate the construction area. This fencing will be erected in a such a manner which will not impact on the structural integrity of the Limestone pavement. The vegetation associated with the Limestone pavement will be removed as part of the site clearance prior to the installation of the Limestone pavement protection system detailed in **Section 2.3**. No machinery will be located on top of the Limestone pavement without the protection system in place. Any vegetation on top of the Limestone pavement will be removed using hand held equipment. Vegetation will be cut only and will not be up-rooted. The protection system will be put in place anywhere there is the potential for interaction between construction work and the Limestone pavement.

## 2.3 Stage 2 – Construction of the Limestone pavement protection system

The area of Limestone pavement to be protected is approximately 5,750m$^2$. The function of the Limestone pavement protection system is to safeguard the structural integrity of the Limestone pavement from loading associated with the viaduct construction that could potentially cause structural damage. In order to design the protection system required it is necessary to understand the construction loadings and duration.

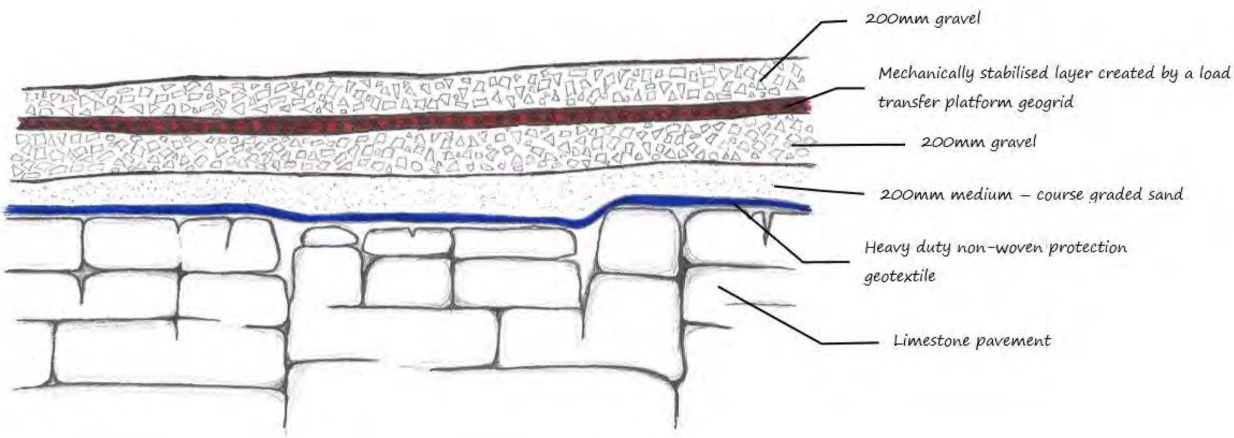
The construction of Menlough Viaduct is anticipated to take 18 to 24 months. During this time, both tracked and untracked machinery will be used depending on the terrain. A non-exhaustive list of the construction machinery expected to be used during the construction period consists of excavators, cranes, dump trucks, loaders, roller trucks and concrete equipment.

The anticipated applied loading on the ground due to construction is in the range of 35-50kN/m$^2$. This is the total load anticipated inclusive of the wet concrete, construction machinery and falsework, where applicable. The loading will be intermittent and not confined to one single location. This is the expected loading on the area of Limestone pavement only, other loadings will apply at other locations.

The protection system will incorporate layers of materials to firstly protect the surface of the Limestone pavement but also to redistribute the construction loadings and avoid point loads which may cause induced cracks to the surface of the Limestone pavement. **Figure 2.3** below shows an indicative sketch of this protection system which is made up of the following:

1. A heavy duty non-woven protection geotextile layer on the surface of the Limestone pavement
2. A layer of sand to form a level surface and protect the geotextile from tearing due to the gravels
3. A layer of gravels to provide stability and an interlocking system for the load transfer platform geogrid
4. A load transform platform geogrid to redistribute the point loadings and provide a mechanically stabilised layer and a safe working platform for construction
5. A layer of gravels to provide an interlocking system for the mechanically stabilised layer and clause 804 or similar surface for construction traffic to traverse

**Figure 2.3: Limestone pavement protection system**




### 2.3.1 Geotextile protection layer

Standard geotextile membranes are permeable nonwoven fabrics which when used in association with soil, have the ability to separate, filter, reinforce, protect or drain. The protection geotextile layer will be used to prevent the sand and granular material from seeping into grykes associated with the Limestone pavement. A heavy duty non-woven protection geotextile will be used in this instance. The protection geotextile shall have a good elongation as this will help mould the layer around the clinks and grykes of the Limestone pavement and provide full protection as the geotextile is designed to deform in such a way. This layer will act as the first layer of protection to the surface of the Limestone pavement. As such it is important that this layer is of sufficient strength as to not tear or puncture, and shall have a min strength of 46 – 55 kN/m and a minimum pore sizing of approximately 65-75 µmm. This is to prevent any seepage of sand into the grykes of the Limestone pavement. The heavy duty non-woven protection geotextile shall be crane lifted from outside the Limestone pavement to the start of the protection area. The geotextile can be rolled out and laid manually on site without the need for any heavy machinery.

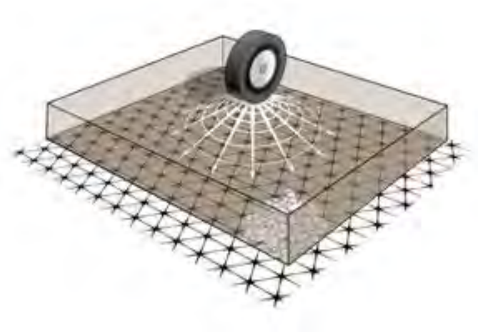
### 2.3.2 Sand layer

A layer of fine sand will be placed on top of the geotextile protection layer to protect the material from any tearing due to the angular gavels which will be used with the structural geotextile membrane for distributing the loading. The sand layer shall be built up and compacted to form a level surface above the Limestone pavement. The sand layer is required to be a medium to coarse graded sand in accordance with ISO EN 14688. Particle sizes in the range of 0.2mm to 2.0mm will be used which will provide enough flexibility to even out the surface while also large enough not to seep through the geotextile.

### 2.3.3 Geogrid load transfer platform

Geogrid load transfer platforms (LTP) are most commonly used in the construction of piled foundations on soft ground. The LTP acts to disperse the applied loading to the entire foundation and not solely to the supporting pile foundations. Similarly, this can be applied to the areas of Limestone pavement. Without the LTP the applied loading would concentrate on the first contact point with the Limestone pavement, such a loading would likely cause the Limestone pavement to fracture or break. However, the inclusion of the LTP, as can be seen in **Figure 2.4** below, results in the loading being diffused and applied over the entire pavement area. A material which can achieve this load dispersal, and in particular disperse loads in a multi-directional pattern, shall be utilised. This type of geogrid has near isotropic tensile properties which leads to a mechanically stabilised layer.

**Figure 2.4: Radial loading dispersion of geogrid load transfer platform** (Tensar International, 2010)



These type of geotextiles have been used in other infrastructure projects in Ireland and the UK, for example A2 Maydown to City of Derry Airport and Arecleoch Windfarm South Aryshire. As Limestone pavement is not an engineered material and given the high variability in shapes and size, demonstration of performance of the protection system will need to be undertaken by trials. The trials shall be carried out by the appointed contractor and shall consider and test numerous combinations of load intensity and configurations of structures that replicate the variability of Limestone pavement. The trials shall be undertaken prior to being implemented on site. Only products which have undergone multiple rigorous tests that can ensure the protection of the underlying Limestone pavement will be used for the Limestone pavement protection system.

### 2.3.4 Gravel layer

A 200mm layer of 100-150mm graded stone will be placed above and below the load transfer geogrid. The stone layers will interlock with the triangular openings of the geogrid to form a stable layer of suitable stiffness as can be seen in **Figure 2.5** below.

**Figure 2.5: Interlocking of stone layer with geogrid (Tensar International, 2010)**

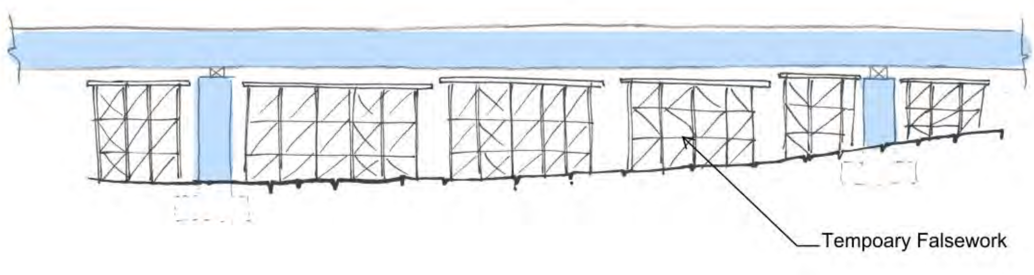
The protective system will be finished with a suitable surface such as clause 804 to enable construction traffic to traverse the area.

## 2.4 Stage 3 – Viaduct construction

Temporary falsework will be constructed above the Limestone pavement protection system to below the soffit of the bridge deck as shown in **Figure 2.6**. This will allow the necessary construction platform to construct the viaduct, for example for a concrete bridge the in-situ concrete could be poured and then post-tensioned or for a steel bridge, the steel sections can be lifted into place and connections fitted.

No construction works are permitted within the area of the Turlough itself. At both the local road and the Turlough a temporary spanning structure will be utilised to support the formwork for the construction activities. Where in situ concrete is used for the superstructure, it is expected that a temporary bridging structure would be built over the Turlough to permit construction from below the proposed deck. For construction methods using prefabricated elements, the lifting of these elements above the Turlough will be undertaken using lifting equipment located at a suitable distance from the Turlough to avoid any impact. A netting system will also be used over the Limestone pavement and Turlough area to catch any falling debris or materials. This will ensure that no damage occurs to the Limestone pavement or Turlough environment beneath.

**Figure 2.6: Construction with temporary falsework**



## 2.5 Stage 4 – Completion of works

Once the viaduct structure is complete all construction related material will be removed, including the Limestone pavement protection system. The removal of this protection system is an important aspect of ensuring the physical structure of the Limestone pavement is intact.

The removal will be done in a similar staging as to how it was constructed. The initial layers of the gravel and geogrid will be removed followed by the sand and the protective geotextile layer. The protective geotextile layer shall be manually rolled back off the Limestone pavement and crane lifted away from the site. No machinery will be located on top of the Limestone pavement during this activity.

# 3 Construction Method 2

The second construction method presented is the balanced cantilever system and is less invasive on the protected habitats as the ground is not used as a platform for the construction works. The construction works will be restricted to minimise direct contact with the Limestone pavement and avoid direct contact with the Turlough. It should be noted that where balanced cantilever methods are used, it will not be for the full length of the bridge and some parts of the bridge will be constructed using Construction Method 1.

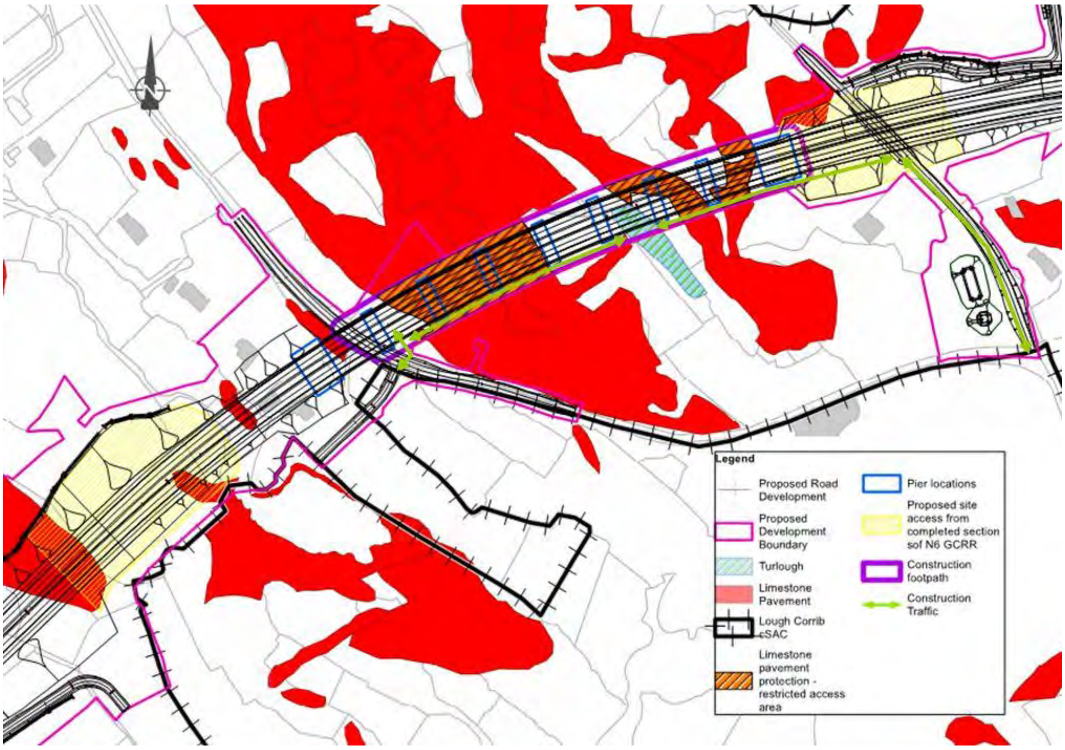
The stages of the construction under this methodology are as follows:

- Stage 1 - Site access and enabling works
- Stage 2 - Viaduct construction
- Stage 3 - Completion of works

## 3.1 Stage 1 – Site access and enabling and works

As described in **Section 2.2**, the proposed road highlighted in blue in **Figure 3.1** will be constructed first and will be used for site access to construct the viaduct. There will also be limited construction traffic from Bóthar Nua and Sean Bóthar as shown in green in **Figure 3.1**. Areas of Limestone pavement will need to be protected temporarily during the construction, using the protection system described in **Section 2.3**. This protection system will be put in place anywhere there is the potential for interaction between construction work and the Limestone pavement and under the footprint of the structure to protect the Limestone pavement in the event of any falling debris or materials during construction. Access will be restricted to the main area of Limestone pavement beneath the large span of the structure and to the Turlough.

**Figure 3.1: Construction Method 2 Site Access**



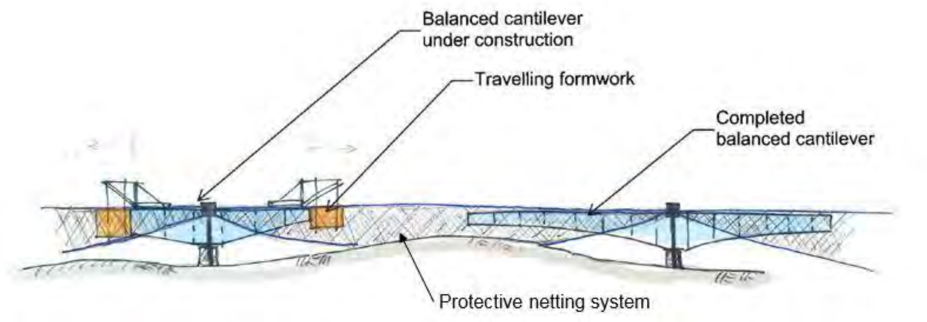

The proposed development boundary fencing will be erected to isolate the construction area as outlined in **Section 2.2** of this report.

## 3.2 Stage 2 – Viaduct Construction

The balanced cantilever method with travelling forms would be adopted as shown in **Figure 3.2** to construct the viaduct and avoid the need for temporary supports over the large area of Limestone pavement beneath the main span.

As described in **Section 3.1** access to the site would be gained from the proposed N6 GCRR east and west of the viaduct location and construction traffic such as concrete trucks or cranes would be able to travel to the site location via these sections of the N6 GCRR. In the case of a concrete bridge the in-situ concrete can be poured from these sections of the N6 GCRR. For further mitigation details refer to Section 8 Sediment, Erosion and Pollution Control Plan, of the CEMP The concrete will be pumped as the formwork continues to progress further along the structure. For the shorter spans, particularly over the Turlough, the balanced cantilever could also be continued. Where in situ concrete is used for the superstructure, it is expected that a temporary bridging structure would be built over the Turlough to permit construction from below the proposed deck. For construction methods using prefabricated elements, the lifting of these elements above the Turlough will be undertaken using lifting equipment located at a suitable distance from the Turlough. For a steel bridge the steel girders would be lifted into place using a crane located on the constructed N6 GCRR.

**Figure 3.2: Balanced cantilever construction method**




This is a less invasive construction methodology as it avoids any large scale construction works off the Limestone pavement, although, some parts of the bridge will be constructed using Construction Method 1. A netting system will also be used over the Limestone pavement and Turlough area to catch any falling debris or materials. This will ensure that no damage occurs to the Limestone pavement environment beneath.

## 3.3 Stage 3 – Completion of works

As some of the works are completed from the western and eastern approaches to the structure and not off the ground itself, the removal and reinstatement works are reduced with this option. All construction related material will be removed following completion of the works and the Limestone pavement protection system will be removed in the reverse to how it was installed as discussed in **Section 2.5** of this report. The protective netting will also be removed on completion of the viaduct construction.

# 4 Construction Method 3

The third construction method presented is a prestressed precast beam superstructure construction method. This method is similar to Method 1; the protection measures to the Limestone pavement are required for access and craning of the precast elements.

The stages of the construction under this methodology are as follows:

- Stage 1 - Site access and enabling works
- Stage 2 - Viaduct construction
- Stage 3 - Completion of works

## 4.1 Stage 1 – Site access and enabling and works

As described in **Section 2.2**, the proposed road highlighted in blue in **Figure 2.2** will be constructed first and will be used for site access to construct the viaduct. There will also be limited construction traffic from Bóthar Nua and Sean Bóthar as shown in green in **Figure 2.2**. Areas of Limestone pavement will need to be protected temporarily during the construction, using the protection system described in **Section 2.3**. This protection system will be put in place anywhere there is the potential for interaction between construction work and the Limestone pavement and under the footprint of the structure to protect the Limestone pavement in the event of any falling debris or materials during construction.

The precast beam method will require the use of mobile cranes to lift and place the beams in position. An appropriate temporary platform will be required at discrete locations to position the cranes for lifting of the precast beams. These temporary platforms will be provided with the protection system described above. The proposed development boundary fencing will be erected to isolate the construction area as outlined in **Section 2.2** of this report.

## 4.2 Stage 2 – Viaduct Construction

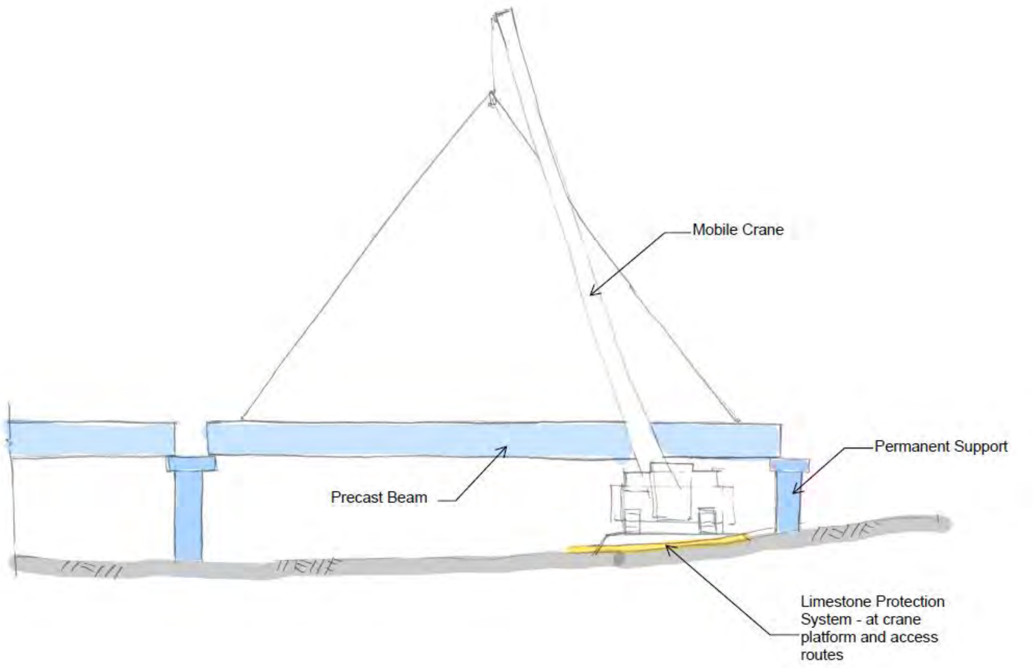
The precast beams will be lifted into position in span by span. The precast beams will be placed on the permanent supports and no temporary supports are envisaged within spans. See **Figure 4.1**. Where tall and slender precast beams are used, such as SY beams, the appropriate measures to ensure stability during lifting and concreting of the deck are necessary. This should include the use of permanent drop-heads at the support locations and the necessary temporary works to restrain the beams rotation at the ends. The temporary works are to use the permanent pier as the supporting structure, and not the ground below.

For the span over the Turlough, a tandem lift is expected, whereby two cranes are used, positioned on each side of the Turlough.

As described in **Section 4.1** access to the site would be gained from the proposed N6 GCRR east and west of the viaduct location and construction traffic such as concrete trucks or cranes would be able to travel to the site location via these sections of the N6 GCRR. An insitu deck slab will be provided above the precast beams, with the concrete supply being provided by trucks adjacent to the bridge.

This construction methodology avoids any large scale construction works off the Limestone pavement. A netting system will also be used over the Limestone pavement and Turlough area to catch any falling debris or materials. This will ensure that no damage occurs to the Limestone pavement environment beneath.

**Figure 4.1: Prestressed Precast Beam Superstructure Construction Method**




## 4.3 Stage 3 – Completion of works

All construction related material will be removed following completion of the works and the Limestone pavement protection system will be removed in the reverse to how it was installed as discussed in **Section 2.5** of this report. The protective netting will also be removed on completion of the viaduct construction.

# 5 Summary and Conclusions

This report outlines three viable construction options for constructing Menlough Viaduct, Construction Method 1 and Method 3 includes the construction of a protection system over the Limestone pavement and using this as a construction platform and Construction Method 2 utilises the balanced cantilever system.

Although all construction methodologies will affect the vegetation associated with the Limestone pavement habitat, it is not envisaged that there will be any permanent residual impacts to the structural integrity of the Limestone pavement following the construction of the Menlough Viaduct using any of these three methods with the exception of the removal of Limestone pavement for one of the pier locations. The Limestone pavement protection system has sufficient capacity to withstand the predicted construction loading. The geotextile protective layer, as demonstrated, will act as a barrier between the Limestone pavement surface and the sand and granular layers of the protection system. The geogrid has the capability to disperse any point loading and therefore protect the Limestone pavement from cracking or any structural damage. The Turlough will be clear spanned and no construction will take place within this area to avoid any direct impacts on this habitat area.

All of the construction methodologies described incorporate the need to protect the structural integrity of the Limestone pavement and to ensure the Turlough is not directly affected by construction works.

# 6 References

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