Structures – concrete

This section includes summary sheets for the following technical solutions:

- Precast concrete rather than cast in-situ;
- Assemble structures on site and move into place;
- Recycled/secondary aggregates in concrete;
- pfa and ggbs as cement replacement materials; and
- Gabions or other geosystems for soil retention and erosion protection.
**TECHNICAL SOLUTION: Structures – concrete**

**Precast concrete rather than cast in-situ**

**Application:** Various structural elements for highways, railways, utilities, harbours, docks and waterways, and power generation.

**Designing out Waste Principle:** Design for Off Site Construction.

**What is it?**

The benefits of off site factory production, or controlled prefabrication on site or at a nearby location, are well documented. Assembling the precast units on site and then moving them into place has the potential to significantly change operations on site, reducing the number of site activities and changing the construction process into one of a rapid assembly of parts that can provide many environmental, commercial and social benefits. Generally a better quality product can be produced by precast techniques and the need for temporary works may be reduced.

Assembling structures in this way is one of a group of approaches to more efficient construction sometimes called Modern Methods of Construction that also include prefabrication, improved supply chain management and other approaches. It should be noted that these techniques are already extensively applied in the building construction industry from which many lessons can be learned.

**Where can I use it?**

Precast beams and bridge units are frequently used for constructing road, rail and foot bridges and box culverts are precast prior to jacking them beneath embankments. In replacement situations, the new structure is built alongside the existing one, which is then demolished and the new structure moved into place as a unit. The main driver for this method of construction is that it minimises closure or disruption of the road or railway, but it also allows more efficient construction of the new structure with reduced waste compared to constructing it in stages while keeping the road/railway functioning. In all cases, the methods of construction need to be considered at the preliminary design stage.

The use of precast units for rapidly constructing low height modular retaining walls, such as those needed for slope retention and silo installation, is already well established in the civil engineering industry. Precast pipes are also extensively used.

**How do I apply it?**

WRAP (2007) *Current practices and future potential in modern methods of construction*. Case history studies are also reported by WRAP in *Waste reduction potential of precast concrete manufactured off site*.

For concrete structures, the Concrete Centre and the British Precast Concrete Federation are amongst those organisations providing advice on modern methods of construction and precasting techniques.


**Why should I use it?**

- **Waste reduction:** has the potential to significantly reduce waste produced on site.
- **Cost reduction:** efficient precasting techniques may reduce costs.
- **Recycled content:** opportunities may exist for increasing the recycled content during prefabrication.
- **Programme:** rapid on site assembly of the structure reduces construction timescales.
- **Carbon footprint:** minimises delay to road, rail and other users so improving fuel efficiency.
- **Other environmental benefits:** less disruption in terms of noise, dust, and vibration because of faster construction.
Assemble structures on site and move into place

**Application:** Various structural elements for highways, railways, utilities, harbours, docks and waterways, and power generation.

**Designing out Waste Principle:** Design for Off Site Construction.

**What is it?**

The benefits of off site factory production, or controlled prefabrication on site at a nearby location, are well documented. Assembling these structures on site and then moving them into place has the potential to significantly change operations on site, reducing the number of site activities and changing the construction process into one of a rapid assembly of parts that can provide many environmental, commercial and social benefits.

Assembling structures in this way is one of a group of approaches to more efficient construction sometimes called Modern Methods of Construction that also include prefabrication, improved supply chain management and other approaches. It should be noted that these techniques are already extensively applied in the building construction industry from which many lessons can be learned.

**Where can I use it?**

Assembly on site is now frequently used as a method of construction of road, rail and foot bridges and for installing box culverts beneath embankments. In replacement situations, the new structure is built alongside the existing one, which is then demolished and the new structure moved into place as a unit. The main driver for this method of construction is that it minimises closure or disruption of the road or railway, but it also allows more efficient construction of the new structure with reduced waste compared to constructing it in stages while keeping the road/railway functioning.

The existing structure can then be demolished or dismantled more efficiently, allowing greater recovery and reuse of its materials for future projects.

The use of precast units for rapidly constructing low height modular retaining walls is already well established in the civil engineering industry.

In all cases, the methods of construction need to be considered at the preliminary design stage.

**How do I apply it?**


For concrete structures, the Concrete Centre and the British Precast Concrete Federation are amongst those organisations providing advice on modern methods of construction.


**Why should I use it?**

- **Waste reduction:** has the potential to reduce waste produced on site.
- **Cost reduction:** efficient prefabrication may reduce costs.
- **Recycled content:** opportunities may exist for recycling during prefabrication.
- **Programme:** minimises disruption to transport networks by rapid on site assembly of the structure reducing construction timescales.
- **Carbon footprint:** minimises delay to road, rail and other users so improving fuel efficiency.
- **Other environmental benefits:** less disruption in terms of noise, dust, and vibration because of faster construction.
**TECHNICAL SOLUTION: Structures – concrete**

**Recycled/secondary aggregates in concrete**

**Application:** Construction and maintenance of concrete structures.

**Designing out Waste Principle:** Design for Reuse and Recovery.

**What is it?**

At the moment recycled aggregate is restricted to replacing coarse aggregate (>4mm) which precludes the use of most secondary aggregates. It is likely that suitable recycled aggregate will be obtained from two main supply streams, either preconsumer waste from concrete production (precast or ready mix concrete plants) or from demolition projects such as disused airfield structures, concrete framed or clad buildings. This ensures a relatively high quality material with <5% brick and <1.0% impurities. Potential sources need to be able to provide sufficient quantity, consistent quality and usually be fairly close to the site where the concrete is to be used to ensure that the economics are viable.

**Where can I use it?**

The use of recycled aggregate in structural grade concrete is relatively new. Hence, the usage of Recycled Concrete Aggregate (RCA) is not advised for use in particularly sensitive or critical structural elements or structures until it has a longer track record. In some applications RCA is used as a partial replacement for primary aggregate and may be used up to the 20% replacement level; however, it may be possible to use it up to the 60% replacement level with the overseeing engineer’s approval.

**How do I apply it?**

Requirements for RCA for use in concrete in general are indicated in BS 8500-2:2006.

The SHW 1702.2 states that ‘Unless otherwise specified in Appendix 17/4, aggregates shall conform to the British Standards listed in 4.3 of BS 8500-2 except that recycled concrete aggregate (RCA) and recycled aggregate (RA) shall not be used’. However, this is dated May 2004 and conflicts with BA 92/07 dated May 2007. It is advised that a departure should be applied for use of RCA and RA in accordance with Chapter 7 of BA 92/07.

BA 92/07 is an Advice Note in the Design Manual for Roads and Bridges entitled The use of recycled concrete aggregate in structural concrete and provides information on the use of RCA as a replacement for coarse natural aggregates in structural grade concrete, [www.standardsforhighways.co.uk/dmrb/vol2/section3/ba9207.pdf](http://www.standardsforhighways.co.uk/dmrb/vol2/section3/ba9207.pdf)

It encourages designers, contractors and concrete suppliers to consider the use of RCA.

The WRAP Research Report on Mix design specification for low strength concretes containing recycled and secondary aggregates provides guidance.

TRL PPR36 The use of recycled aggregate in structural concrete gives details of performance testing to determine engineering properties and durability.

**Why should I use it?**

- **Waste reduction:** the use of recycled aggregates reduces the quantity of waste disposal to landfill.
- **Cost reduction:** is often cheaper than using primary aggregates.
- **Recycled content:** increases the recycled content of the scheme.
- **Programme:** no significant impact on programme.
- **Carbon footprint:** the use of waste materials are usually available locally, therefore there is a saving on transport in lorry movements and fuel.
- **Other environmental benefits:** reduction in congestion, noise, vibration and fumes by reduction in lorry movements. Reduced resource depletion.
**TECHNICAL SOLUTION: Structures – concrete**

**pfa and ggbs as cement replacement materials**

**Application:** Construction of pavements, piles and retaining walls for highways, airports, utilities, harbours, docks and waterways, power generation and in development of brown- and greenfield sites, structural concrete for railways.

**Designing out Waste Principle:** Design for Reuse and Recovery.

**What is it?**

Concretes mixes where a proportion of the cement is replaced by pulverised fuel ash (pfa) or granulated blastfurnace slag (ggbs) result in reduced early-age thermal cracking in thick concrete sections because of the low heat evolution during hydration. 

Cements containing materials such as pfa and ggbs have been used for many years and both act to limit the temperature rise during hydration and hence thermal cracking. There is potential for their increasing usage in pavement, pile and retaining wall construction. Although the strength gain with time is slower than with conventional concrete, in the longer term higher strengths are attained.

**Where can I use it?**

Pozzolans, like pfa and ggbs, have not gained popularity in fast track construction because of their slower strength gain at standard curing temperatures – however where time constraints do not exist they may produce a more durable and ultimately higher strength concrete. For example cement replacement is considered to enhance resistance to sulphate attack and to alkali-silica reaction. In addition there is some evidence that pfa or ggbs have the effect of reducing permeability to both gases and liquids so encouraging their usage in particular applications such as cut-off walls.

**How do I apply it?**


BS EN 197-1:2000 (Composition, specifications and conformity criteria for common cements) gives the allowable compositions of cements incorporating pfa or ggbs. The ICE specification for piling and embedded retaining walls permits the use of cement replacement materials provided they can be shown to have no deleterious effects.

Details of the recommended levels of replacement are given in the Specification for Highway Works, Clause 1001.3 [www.standardsforhighways.co.uk/mchw/vol1/pdfs/series_1000.pdf](http://www.standardsforhighways.co.uk/mchw/vol1/pdfs/series_1000.pdf) and the associated Notes for Guidance, Clause 1001.10 [www.standardsforhighways.co.uk/mchw/vol2/pdfs/series_ng_1000.pdf](http://www.standardsforhighways.co.uk/mchw/vol2/pdfs/series_ng_1000.pdf)

Network Rail – Model Clauses for Civil Engineering Works, Section 80, Structural Concrete, Clause 80.005 indicates the replacement levels allowed and applications for pfa, ggbs and microsilica.

**Why should I use it?**

- **Waste reduction:** the use of waste/by-product materials for cement replacement reduces the quantity of cement used.
- **Cost reduction:** some reduction in the cost of procuring cement.
- **Recycled content:** replaces cement with alternative materials (e.g. up to 50% pfa and 65% ggbs in the SHW).
- **Programme:** no significant impact on programme.
- **Carbon footprint:** the use of waste/by-product materials reduces the embodied carbon associated with cement.
- **Other environmental benefits:** obviates need to dispose of waste materials by other means. Reduced resource depletion.
**Application:** Various structural elements for highways, railways, development site infrastructure, utilities, harbours, docks and waterways, and power generation.

**Designing out Waste Principle:** Design for Material Optimisation.

**What is it?**

In some cases, it may be possible to replace concrete structures with solutions based on geosystems, such as gabions, crib walls, reinforced soil, anchored earth and soil nailing. Geosystems often enable the use of soils already present on site, possibly with the addition of a binder such as lime or cement, so reducing the waste produced by excavation and the need to import higher quality fill material. Geosystems are often hybrid structures comprising engineered geocomponents such as meshes, strips, boxes, tubes, facing units made of steel, concrete, timber, polymeric or geosynthetic materials.

Where conventional concrete or steel structures are replaced by geosystems, significant savings in the carbon footprint can be achieved.

**Why should I use it?**

- **Waste reduction:** has the potential to significantly reduce waste produced on site.
- **Cost reduction:** can often be a low cost solution.
- **Recycled content:** opportunities may exist for increasing the recycled content by reusing materials on site.
- **Programme:** site specific, but is likely to be faster to install than using some conventional techniques.
- **Carbon footprint:** geosystems can have a low contribution to embodied carbon compared to some conventional techniques.
- **Other environmental benefits:** minimises the amount of materials that have to be brought on site. Utilising materials on site can reduce resource depletion.

**Where can I use it?**

Geosystems are particularly suitable for low height modular retaining walls, although full height structures can be constructed depending on the geosystem being employed. In highway, railway and waterway situations they are frequently employed for soil retention and to improve slope stability. In coastal and marine environments, geosystems can perform the functions of both retaining soil and protecting against erosion.

Geosystems are frequently used for developing site infrastructure where earthworks are required to create a level platform for construction.

**How do I apply it?**

Guidance on the use of geosystems, including applications, case studies and the waste and carbon savings that can be achieved is available in the geosystems module of AggRegain www.aggregain.org.uk/geosystems Technical guidance on the use of individual techniques is available in civil engineering textbooks and in the standards and specifications of the infrastructure owner.
This information is an extract from
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