Humes

Strength. Performance. Passion.

One piece arches Installation guide

August 2024

Contents

Introduction

This guide outlines the construction procedures and specifications required for the trouble free installation of one piece arch systems. Humes' one piece arch systems are classified into BEBO® and Classic arches as shown in Appendix 1.

This guide is not relevant to the installation of two piece arch systems. A separate handling and installation guide is available for these types of systems. Humes will supply copies of this document on request.

Prior to commencement of any project, all supervisory personnel should carefully review this guide. Reference should also be made to Humes one piece arch systems General Assembly standard drawings for typical installation requirements or project specific drawings for General Assembly, prepared by Humes engineers.

Note that Humes drawings are system assembly drawings and do not constitute a site general layout which is provided for and specified in the owner's consulting engineer's project documents.

This guide should be read in conjunction with the specific project contract documents. Where the contents of this guide differ from the contract documents, the requirements of the contract documents will govern. Supervisory personnel should however consult with Humes engineers where differences between the project contract documents and this guide are identified.

The information presented in this guide is for general construction purposes only. Applications of the one piece arch system and the specific data for each installation must be evaluated by the owner or their consulting engineer to determine site suitability, possible site access problems for plant, and other constructability issues.

In the event of any conflict between information in the guide and local legislative requirements, the legislative requirements shall take precedence.

Statements in this guide are not to be construed as either guarantees or implied warranties. Satisfactory adherence to this guide will not discharge the contractor from the contractual requirements of the project.

Recommendations

The main contractor/erection contractor should also produce a Safe Work Method Statement specifically for the erection of the arch structure.

In the planning stages for the footings and erection a sample shopping list (Appendix 2 on page 24) should be prepared and then amended to be project specific at a pre erection meeting held on site one to two weeks prior to erection.

This meeting should be attended by main contractor/erection contractor, crane company and Humes to discuss the shopping list, the Safe Work Method Statement and carry out a site inspection.

Humes site representative

Right:
Humes site representative observing installation

A Humes representative can be made available to assist with pre-planning the delivery & erection process.

Subject to availability on a project-by-project basis and on the days requested, a Humes representative may also attend the construction site during the installation but will act as an observer only.

The unloading, installation and erection of the one-piece arch system is the sole responsibility and the sole risk of the contractor, including as to quality of those works. Humes and its representatives are not obliged to provide any advice to the contractor and is not responsibility for compliance of the site or contractor with any contractual documentation or project requirements. Reliance on any given or comment made by a Humes representative is at the sole risk of the contractor

In-situ footings

Reinforcement and concrete

- Reinforcement should conform to AS 4671.
- Concrete should be a minimum grade N40 to AS 1379.
- Cover to reinforcement for all in-situ work shall be in accordance with AS 3600 Concrete Structures or AS 5100 Bridge Design as appropriate.
- All grout for arch keyway and wingwall dowel holes should be 50 MPa:
  - Minimum cement content: 500 kg/m^3.
  - Maximum aggregate size: 7 mm.
  - Alternatively use bagged proprietary grout.
  - Maximum drying shrinkage: 400 microstrain when tested to AS1012.13
  - Alternatively maximum drying shrinkage 600 microstrain when tested to AS 1012.13 in combination with a waterproofing membrane (similar to that used at arch joints) applied across the outside face surface to the arch o keyway connection (refer to figure 1)

General construction procedure

Excavation

Prior to any excavation work, all underground service conduits must be located, and precautions taken to protect them.

The system's in-situ footings are typically shallow strip footings with supporting piers or piles spaced along its length. Deep excavations for in-situ footings are not common, however where these occur care should be taken.

It is recommended that a suitably qualified geotechnical engineer inspects the open excavation and that any discrepancies between soil properties and those assumed in the design are reported to the superintendent for evaluation.

Construction (Footings)

Construction of the in-situ footings for arch, spandrel and wingwalls should be in accordance with the owner's consulting engineer's contract documents.

Wingwall footing preparation should be in accordance to the recommendations on the Humes General Arrangements (GA) drawings.

Normally the wing walls sit on material with specifications to that shown on the drawings with a blinding layer of 100-150mm thick to set the leveling packers on. The wingwall footing should be cast-integral with the arch strip footing to eliminate the possibility of differential movement between the adjacent first wingwall and the supported spandrel wall.

Levelling pads, shims and shim blocks

To ensure that arch units are laid on a level foundation and uniformly supported along the unit length, a 50 mm nominal allowance is provided between the underside of arch base and the level of the base of the footing keyway for a 400 mm long 50 MPa grout pad or placing of compressed fiber cement sheeting packers 400 mm x 300 mm
(see Appendix 2 on page 24) supplied by the installation contractor.
The width and depth of the keyway also provides an allowance for precast concrete shim blocks supplied by Humes which are placed at the same RL or up to 10mm lower than that of the 400mm x 300mm leveling pads (paving bricks, compressed fiber cement sheeting or hard PVC plastic shims can be used to support the shim blocks at the required level). Refer to Appendix 4 on page 27 for shim block configuration.

Left:
In-situ footing with levelling pads and shim blocks in place

Tolerances and critical dimensions

All in-situ work should generally be in accordance with the requirements of AS 3600 Concrete Structures or AS 5100 Bridge Design as appropriate for quality of workmanship and materials and for tolerances on design dimensions and reinforcement placement.

In addition to these general requirements and to ensure a trouble-free installation with erection time kept to a minimum, special care should be taken in forming three critical areas in the arch foundation. These areas are:

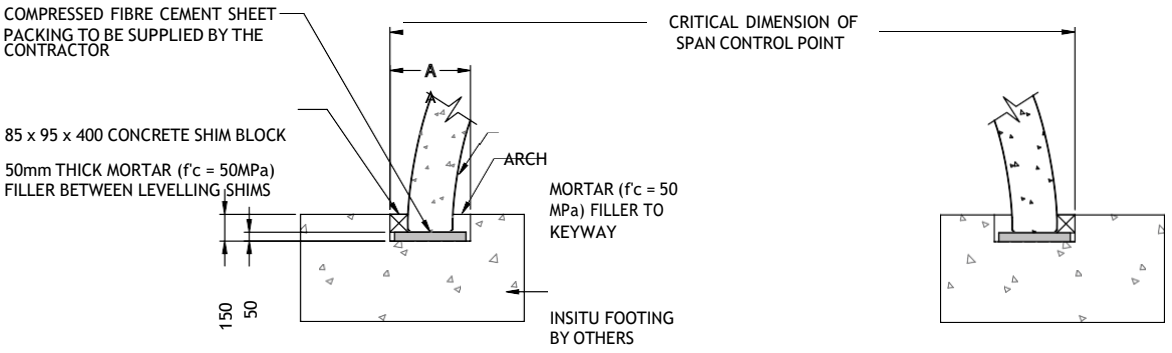
1. the horizontal alignment of the arch keyway
2. the level of the arch keyway
3. the critical dimension to the span control points.

Figure 1 below shows the critical dimension location. Table 1 provides the dimensions of the keyway and the critical dimension between span control points.

Table 1 – Critical dimensions of footings

Arch profile	Keyway dimensions		Critical dimensions (mm)
	Width (mm)	Depth to bottom (mm)	
6210S	400	150	6,600
6310S	400	150	6,600
9300S	450	150	9,700
9400S	450	150	9,700
12300S	470	150	12,660
12400S	470	150	13,100

Figure 1 – Critical dimensions and control points



Scour protection

In most instances where the arch structure is exposed to scouring either during the construction period or the finished operation it is essential that the works be protected.

In particular, where in-situ footings are designed and specified as strip footings without supporting piers or piles, it is critical for the systems structural stability that the integrity of the footing foundation be protected against degradation from the effects of the surfaces water flow.

The final surface treatments for scour protection to the in-situ footings and bed of stream are specified by the site layout design in the owner's consultant engineer's contract documents.

Drainage

The design of the one piece arch system makes no allowance for hydrostatic pressure due to entrapped ground water. It is therefore an essential part of the design that the structure be adequately drained.

Since all element joints within the systems are unsealed butt joints, the free release of ground water occurs at the structure/soil interface. In instances where the arch structure is used to span across roadways and areas accessed by the community, these joints between elements are sealed to prevent water flows and for these cases it is essential that the design include soil drains in the backfill.

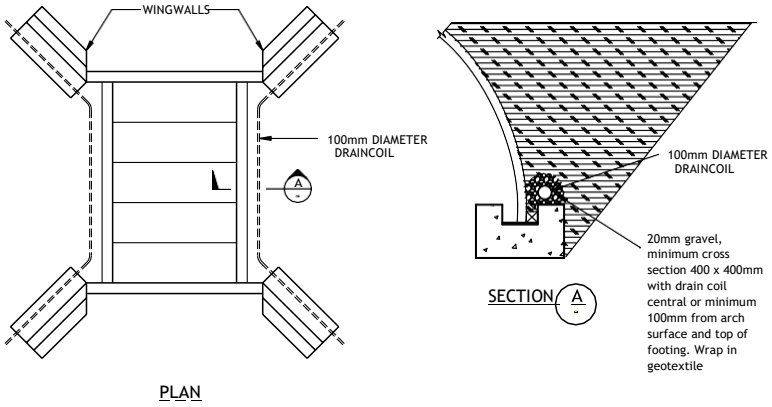
Where the arch structure is located within a tidal zone or within a frequently rising and falling water table, the Zone B backfill material must be enclosed within a suitable filter fabric to eliminate the movement of fines either into or from the placed and compacted Zone B material. Consideration should also be given of weep holes in the arch units which should also be covered with fiber fabric to prevent loss of fines material.
When the single piece arch system is used on an incline, provisions should be made to allow water to be directed away from the structure

Left:
Arch spanning across an existing waterway

Note that the arch structure is designed to act as a soil/structure model. The specified quality and compaction of the backfill surrounding the arch can be adversely affected by groundwater flows and with some materials their supporting strength can be lost in the presence of excess soil water.

As a minimum requirement, the suggested drainage lines are shown in Figure 2 below.

Figure 2 – Suggested drainage lines



Handling of precast arch system elements

General

Wherever possible, all system elements should be lifted from the delivery truck, rotated in midair and set directly onto the prepared footings. However, if circumstances are such that temporary site (or near site) storage of arch units is necessary, ensure that arch units are stored in the "asdelivered" position on hardwood timber pads and on level compacted ground. The location and number of these padsaround the arch perimeter must be the same as those shown (in figure 3) on the delivery truck.

All precast units are supplied with cast-in lifting anchors for handling. To ensure that the units are not over stressed resulting in possible concrete cracking, all units must be handled using the cast-in lifting anchors fitted with lifting clutches.

These lifting clutches should be arranged by contacting the suppliers and it is the installation contractor's responsibility to ensure that they are available on site.

Figure 3 – Arch transportation

Storage and transportation

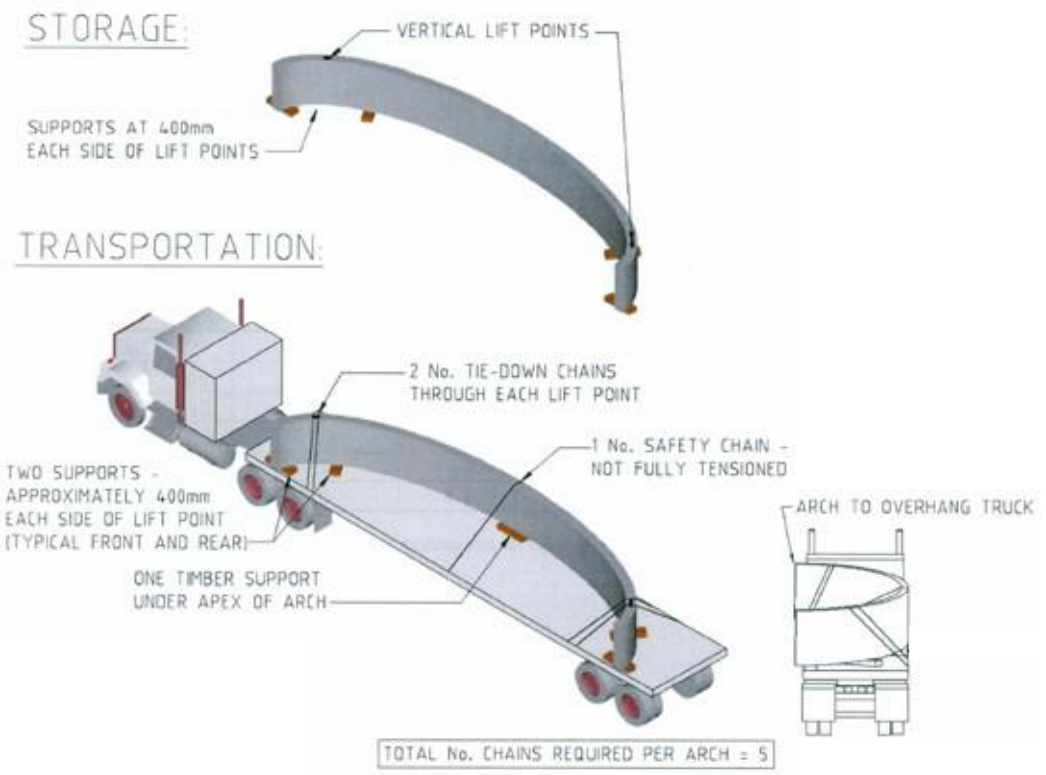
Arch elements

Store and transport only in the vertical position, i.e., perpendicular to the final position, as shown in Figure 3 below.

Table 2 – Arch element widths and masses

Profile	Width (mm)	Unit mass* (tonnes)
6210S	2.5	12.5
6310S	2.5	13.2
9300S	1.8	14.1
9400S	1.8	16.4
12300S	1.8	16.9
12400S	1.8	19.1

*Based on concrete density of 2,500 kg/m^3.


STORAGE:
VERTICAL LIFT POINTS
SUPPORTS AT 400mm
EACH SIDE OF LIFT POINTS
TRANSPORTATION:
2 No. TIE-DOWN CHAINS
THROUGH EACH LIFT POINT
1 No. SAFETY CHAIN -
NOT FULLY TENSIONED
TWO SUPPORTS -
APPROXIMATELY 400mm
EACH SIDE OF LIFT POINT
(TYPICAL FRONT AND REAR)
ONE TIMBER SUPPORT
UNDER APEX OF ARCH
ARCH TO OVERHANG TRUCK
TOTAL No. CHAINS REQUIRED PER ARCH = 5

Spandrel and wingwalls

Both spandrels and wingwalls are transported horizontally except for small wingwalls which may travel upright as shown in Figures 4 and 5 respectively.
Unit masses (based on 120° wingwalls) are shown in Table 3.

Table 3 – Spandrel and wingwall masses*

Profile	Spandrel (tonnes)	Wingwall LD/HD† (tonnes)	Wingwall LD/HD† (tonnes)	Wingwall LD/HD† (tonnes)
6210S	7.8	6.9/9.8	4.8/8.1	N/A
6310S	9.0	8.4/11.3	6.3/9.6	N/A
9300S	12.2	8.4/11.3	6.3/9.6	N/A
9400S	12.2	10.0/13.7	7.9/11.7	5.9/9.0
12300S	17.2	8.4/11.3	6.3/9.6	N/A
12400S	17.2	10.0/13.7	7.9/11.7	5.9/9.0

Notes:
* Based on concrete density of 2,500 kg/m^3
† LD/HD = Light Duty/Heavy Duty.

Figure 4 – Spandrel transportation

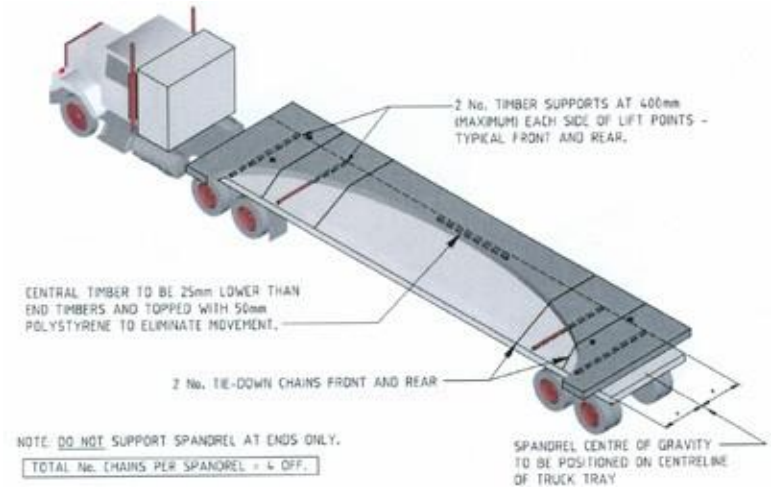
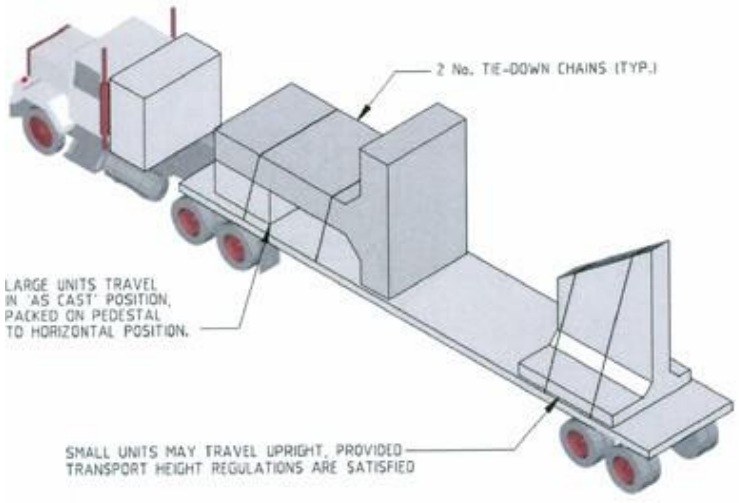


Figure 5 – Wingwall transportation



Erection of precast elements

Arches

Top:
Arch being lifted from truck

Bottom:
Knuckle direction parallel to sling cable

Lifting equipment – Cranes

The contractor is to supply all erection tackle and cables as outlined in the sample shopping list (Appendix 2 on page 24) necessary to install the one-piece arch system elements.

It is the responsibility of the contractor to ensure that the correct lifting capacity crane is available to handle each precast unit. Field conditions should be checked and overhead power lines located well in advance to ensure proper crane location and to avoid any lifting restrictions.

Erection of the arch units
It is recommended that all surveying, bridge set out and placement of leveling ads for arches, spandrel and wingwalls is completed prior to erection day.

Initially the arch unit is lifted vertically using the sling assembly as shown in Figure 6. The cable slings are attached to the arch unit using anchors and lifting clutches. To rotate the arch unit, the sling assembly is used with the rigging as shown in Figure 7.

Next, stretch a stringline the length of each footing in the arch keyway, marking the arch outside span at each footing to indicate the following distance. This dimension should be at least 85 mm away from the outside vertical face of the keyway. Concrete shim blocks, 85 mm wide x 95 mm thick and 400 mm long, are supplied with all arch systems and are used to prevent lateral spreading of the arch at the base supports after placement.

Two shim blocks are placed in the keyway on the leveling pads on the side nearest the crane and, if necessary, they can be rotated and also shimmed with additional smaller PVC packers to align the face of the block with the outside edge of the arch. The blocks are located at the end of the first arch and thereafter at each arch joint spanning between adjacent arches providing a supporting length of approximately 200 mm long at each end of the arch and along the footing.

On the far side leave the shim block out of the keyway up on top of the back side of rebate until the arch has been first set against the shim blocks on the near side. To achieve this it is recommended that the arch sling lengths on the far side be shorter by approximately 150 mm so that the near side of the arch sits down first against the two shim blocks to allow easier alignment to setup marks on the footing (refer to Appendix 4 on page 27).

Figure 6 – Arch element lifting sling connection

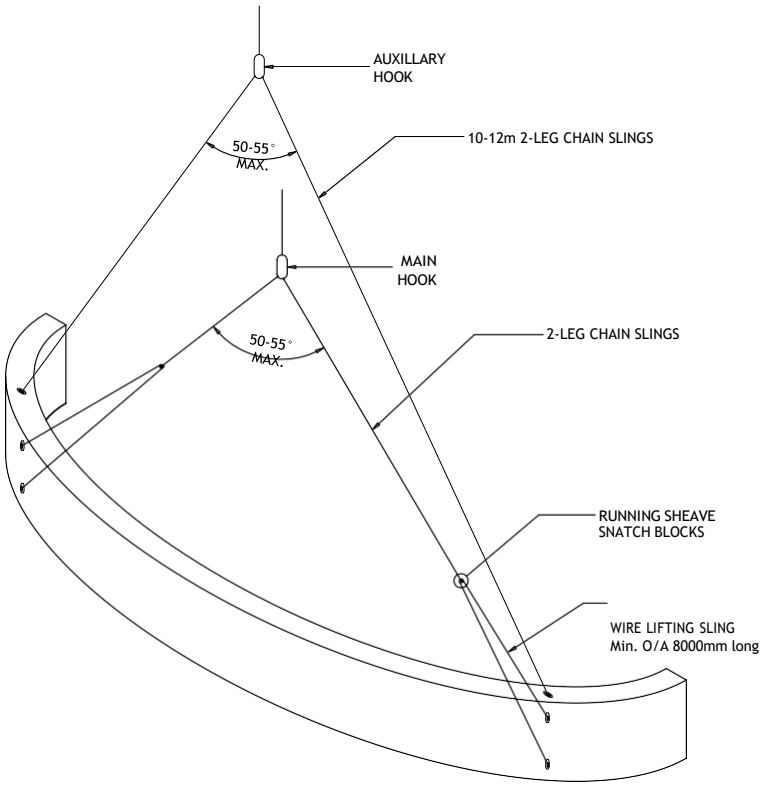
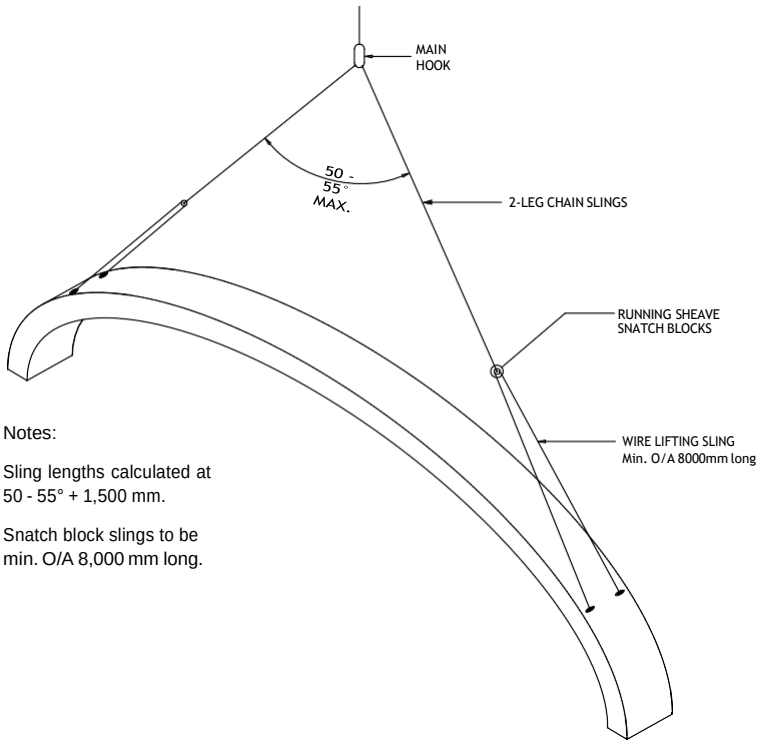


Figure 7 – Rotated arch unit



Notes:

Sling lengths calculated at 50 - 55° + 1,500 mm.

Snatch block slings to be min. O/A 8,000 mm long.

Top:
Checking for plumb before unhooking the crane

Bottom:
Use of PVC packers to accurately space arches

Then lower the shortened side down to sit on the packers, set up and then loosen the arch weight until arch just starts to slide (normally around half the unit weight). Place the shim block in the center of the arch (not at the joint as on the near side), pack firmly with PVC packers and then drop all the arch weight from the crane. The arch should then be checked for plumb before unhooking the crane.

First spacing between the arch units should be approximately 15 mm (10 mm min, 20 mm max.) for arch spans up to 15 m, and approximately 20 mm (15 mm min, 25 mm max.) for arch spans of 15 m and greater, but before installing the elements, measure the length of the arch footing and calculate the exact spacing needed between the arch units.

Measure from the end of the footing to the first joint centerline, allowing for the arch to hang over the end of the footing by 10-15 mm. Then mark the centerline of joints along the top outer rear face of arch footing, once again allowing for the last arch to hang over the footing by 10-15 mm. Arch units should be placed such that a concrete off-form end is adjacent to a hand finished concrete end with edge lifters, except for external arch units where the orientation of ends is controlled by cast-in items for the arch to spandrel temporary erection brackets. It is helpful to have available 5 mm and 10 mm thick PVC packers to assist in spacing the arch units as they are being set.

The final arch unit is located in the keyway. Note that the end arch units differ from the internal units as they typically have cast-in ferrules fitted with temporary tie-back angle brackets for the arch to spandrel connection during erection.

Spandrel walls

The lifting process for the spandrel wall is similar to the arch element, and the same lifting cables are used (see Figure 8 below).

After the spandrel wall has been lifted from the truck and rotated into the vertical position, place it on the footing so that the spandrel wall temporary installation bracket ferrule is aligned with the angle bracket on top of the end arch.

It is necessary to have personnel in position at the top of the arch to align, fit and tighten the temporary installation bracket together whilst the spandrel is still safely held by the crane. Details of the installation bracket are shown in the photo opposite. Once the wingwalls, which support the spandrel, have been erected, the temporary installation bracket should be loosened to allow for movement between arch and spandrel during backfilling.

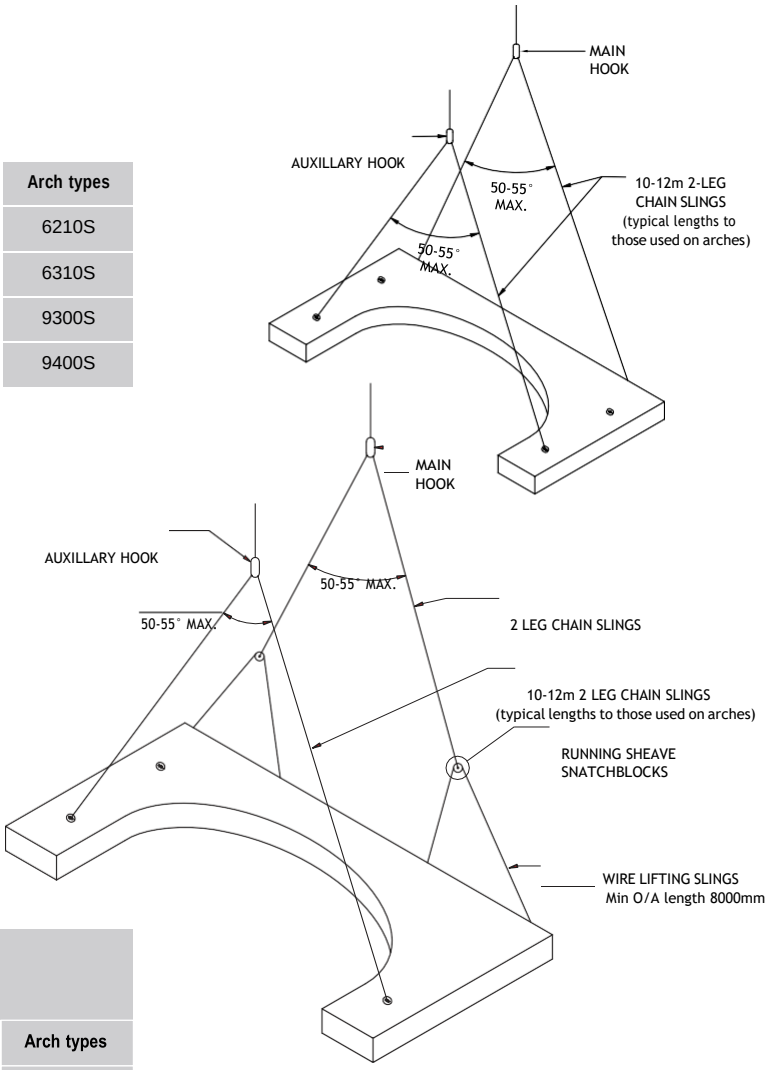
In the case of 180° wingwalls or where no wingwalls are specified, the temporary installation bracket is provided along with tie-bars assemblies connecting spandrel units either across the structure length , or down to the arch footing as shown in the image above, and on the Humes General Assembly drawings. They are installed progressively during the backfilling operations. Again, installation brackets are loosened or removed once the backfilling reaches the level of the installation bracket and all tie-bars assemblies attached to spandrels are tightened and effective in supporting the spandrels.

Tie-bar assemblies are supplied galvanised and wrapped on site with corrosion protection tape. Care should be taken to ensure that the tape is not damaged during backfill placement and compaction.

Installation bracket and, where required, tie-bars are supplied by Humes with the spandrel wall units. The corrosion protection tape wrapping for the tie-bar assembles is supplied by the installation contractor.

Left:
Spandrel secured by tie rods and temporary installation bracket

Figure 8 – Rotation of spandrel



Arch types
6210S
6310S
9300S
9400S

Arch types
12300S
12400S

Wingwalls

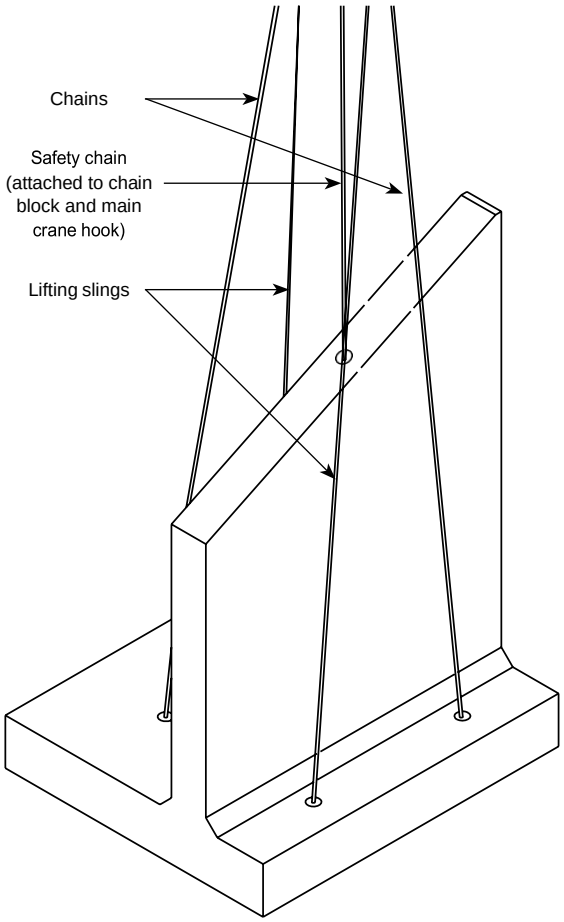
Using both main and auxiliary crane hooks attached to the cast-in lifting anchors, the wingwalls can be lifted and rotated in the air and placed onto flat ground for re hooking, as shown in Figure 9. With the wingwall in the correct orientation it can be lifted onto the prepared foundation as shown.

If the wingwall does not hang level, place a sling with a chain block attached off the main hook of the crane, hook onto the out of level corner lifting knuckle and adjust the wingwall to sit down flat onto the packers.

For assemblies with wingwalls arranged from 90° and up to 120° where the spandrel is supported by the first adjacent wingwall, the joint between the spandrel wall and the first wingwall element should be clean, smooth and uniform so as to provide an even bearing support for the spandrel wall. No mastic jointing material is required to cover this joint, however it is recommended that a 600 mm wide vertical strip of no-fines geotextile is glued to the rear of the wingwall joints to prevent loss of fines.

There are two different types of wingwalls that can be used, light duty and heavy duty.

Figure 9 – Wingwall lifting



Light duty

Light duty wingwalls have an inverted ‘T’ shape and must be placed on an in-situ castconcrete footing. Wingwalls are placed on levelling packers ,typical to those used on arches, located at eachcorner of the wingwall base. Adjacent wingwalls can share equally one set of packers as done with arches.

Dowels and or hold down bolts are generally required to grout the wingwalls to the in-situ footings to resist overturning and sliding of thewingwalls.

Top:
Fully installed wingwalls

Bottom:
Lifting of heavy duty wingwall

Heavy duty

Heavy duty wingwalls have an ‘L’ shape. The placement and installation of these wingwalls is similar to that mentioned about for the light duty wingwall.

Where the natural material is not a suitable foundation, it should be excavated and replaced with compacted granular material. The use of a suitable geofabric material may assist in stabilizing the existing foundation and may be of some benefit in many situations.
The depth of material and its compaction should be determined by site investigations and recommendations of a suitably qualified geotechnical engineer.

Grouting and sealing

Grouting

Top:
Grouting
the keyway

Bottom:
Joints sealed with
mastic tape

After complete installation of the arches and spandrels, the keyway in the arch footings is to be filled with either:

a) A proprietary, flowable, non or low shrinkage 50MPa grout or

b) A flowable 50MPa concrete mix with 7 mm maximum aggregate size, which does not record more than 400 microstrain when tested in accordance with AS 1012.13.

Note that special care should be taken during placement of the grout or concrete mix in the arch footing keyway to ensure that the entire keyway is completely filled such that there are no air gaps remaining around and beneath the arches and spandrels. Where a 50MPa concrete mix is used, it must be either sufficiently flowable or adequately compacted during placement to ensure this.

After the arches, spandrels and wingwalls have been erected, the following areas should be grouted as soon as possible while they are clean and dry:

- The arch footing and spandrel keyways are to be filled over their entire length and adequately compacted to ensure they are completely filled as described above.
- The gap between the underneath side of the wingwalls and the top of the concrete base slab (or strip footings) is to be filled with a flowable grout. Note that if any dowels are required, they should be installed in the dowel holes provided prior to grouting. The perimeter of the wingwall bases is normally sandbagged (or similar) and the grout poured through the nominal 100mm diameter holes in the base of wingwalls.
- All arch lifting anchor recesses, top arch tie rod recesses and spandrel Type A connection recesses are to be filled with a 50MPa dry pack mortar/grout or a 50MPa concrete mix.

Traffic barriers

Where traffic barriers are to be provided, they are to be located in separate footings and should not be connected to the arch elements or the spandrel wall unless first checking with Humes engineers.

Generally it is acceptable to attach pedestrian rails to the top of spandrel wall and wingwalls but again Humes should be consulted.

Left:
Pedestrian rails attached to the top of spandrel and wingwalls.

Backfilling

General

Right:
The no go zone for heavy equipment

The arch backfill specification details provided below are general in nature and may vary for specific projects. The Humes project drawings provide the project specific specification for arch backfill and take precedence.

Backfilling operations at the sides of the arch can commence when the in-situ concrete at the arch units joint at the top of the arch and the footing keyway grouting has at least 20 MPa strength (higher strengths may be required for large arches or arches designed for heavy loads). This can be confirmed by use of concrete cylinder strength testing or by allowing sufficient time after placement of concrete or grout to achieve the required strength (suggested minimum of three days).

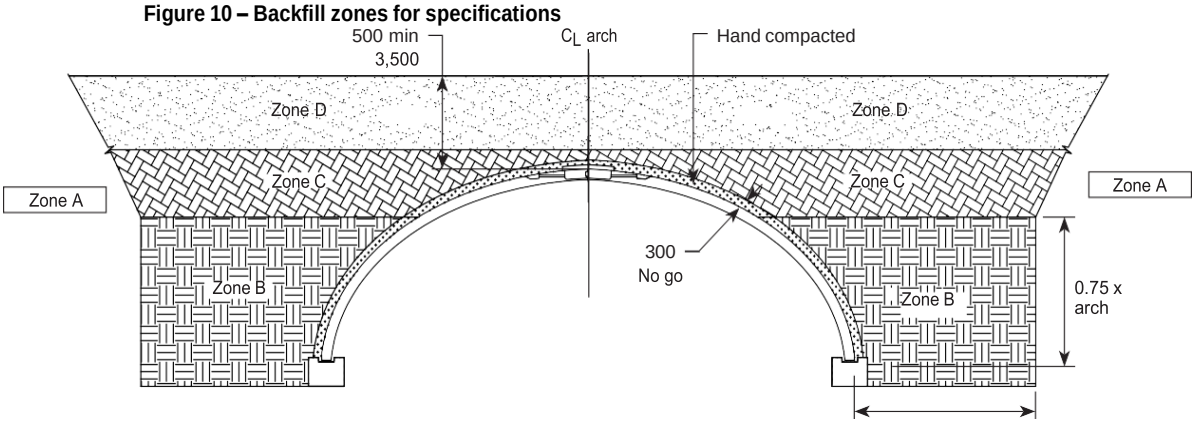
Backfilling over the top of the arch can take place when the in-situ concrete at the top arch joint has at least

30 MPa strength.

This stage of construction represents one of the most important series of load cases experienced by the structure. Damage to the structure can result if the correct procedures are not followed. The critical zones of backfilling are as indicated in Figure 10 below.

Ensure that the no go zone for heavy construction and compaction equipment is maintained during placement and compaction of the backfill material as described under Backfill Compaction on page 30. The no go zone is defined as an area which is a minimum of 300mm from the arch surface and a minimum of 300mm from the rear of the spandrels and wingwalls.

Figure 10 – Backfill zones for specifications



Zone A – Existing natural ground or constructed embankment
Zone B – Side fill necessary for effective arch support
Zone C – Overfill providing uniform loading
Zone D – Road superstructure (including subgrade material and gravel, asphalt or concrete road pavement) or embankment

Zone B

This is the critical zone for the soil/structure model and careful consideration of the material specification for quality and placement is absolutely essential.

The material specification extends vertically up from the in-situ footings 75% of the arch height and extends laterally for a distance equal to the arch height beyond the surface of the arch at the level of the in-situ footing, and may consist of material from one of the following soil groups:

- GW - Gravel or sandy gravel, well graded.
- SW - Sand or gravelly sand, well graded.
- GC - Clayey gravel or clayey sandy gravel.
- SC - Clayey sand or clayey gravelly sand.

Soils within the soil groups and which fall within the grading limits and with a liquid limit equal to or less than 30% and a plasticity index equal to or less than 10 are required provided that these materials, in their compacted state, exhibit an angle of internal friction of not less than 30°.

Apparent gravely materials, which become unstable and break down to become primarily silts and clays when wetted such as shale stone or naturally cemented conglomerates, are not suitable materials and must notbe used.

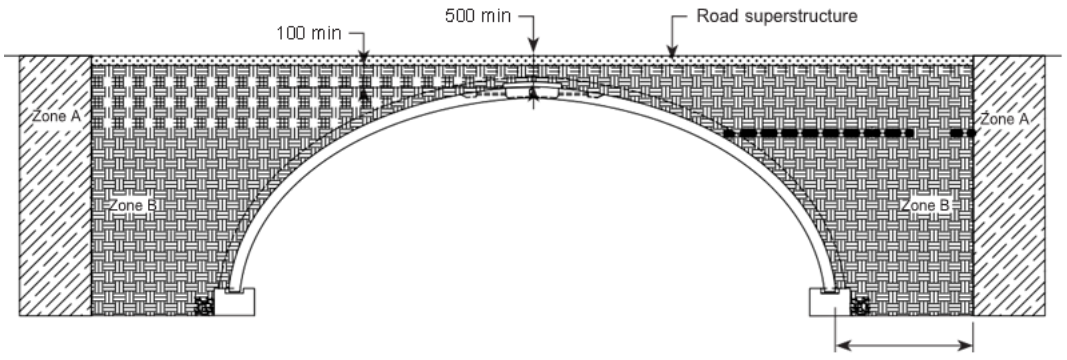
Unsuitable natural materials may become satisfactory when blended with cement or imported materials. Where onsite material outside of the above specification for either grading, liquid limit or plasticity index is to be considered for use as Zone B material, Humes engineers must be consulted.

Note: It is acceptable to use zone B material in place f zone C and zone D material

Table 4 – Zone B material grading limits

Sieve size (mm)	Passing (%)
75	100
9.5	80 - 50
2.36	70 - 30
0.06	50 - 15
0.075	25 - 10

Figure 11 – Low level fills - recommended for overfill up to 600 mm above the arch



Zone C

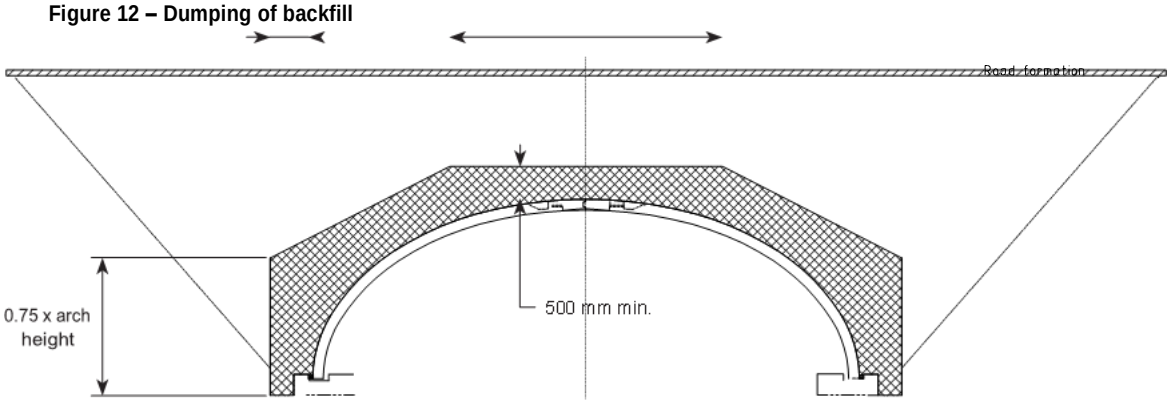
This is the overlay material which extends up to 500 mm above the top of the arch and should be substantially free of organic matter, generally free of stones larger than 150 mm and free of stones larger than 75 mm within 300 mm of concrete surfaces (i.e. arches, spandrels and wingwalls). The material should also have good compaction properties and be easily compacted and stable in place.

Zone D

The road superstructure (including subgrade material and road pavement) or embankment according to the owners consulting engineers project documents.

For low level fill applications where the road pavement (gravel, asphalt or concrete) falls within the Zone C material, then Zone B must extend up to a minimum level of 100 mm above the top of the arch surface prior to placement of the road subgrade material and Zone C material is not used.

Figure 12 – Dumping of backfill



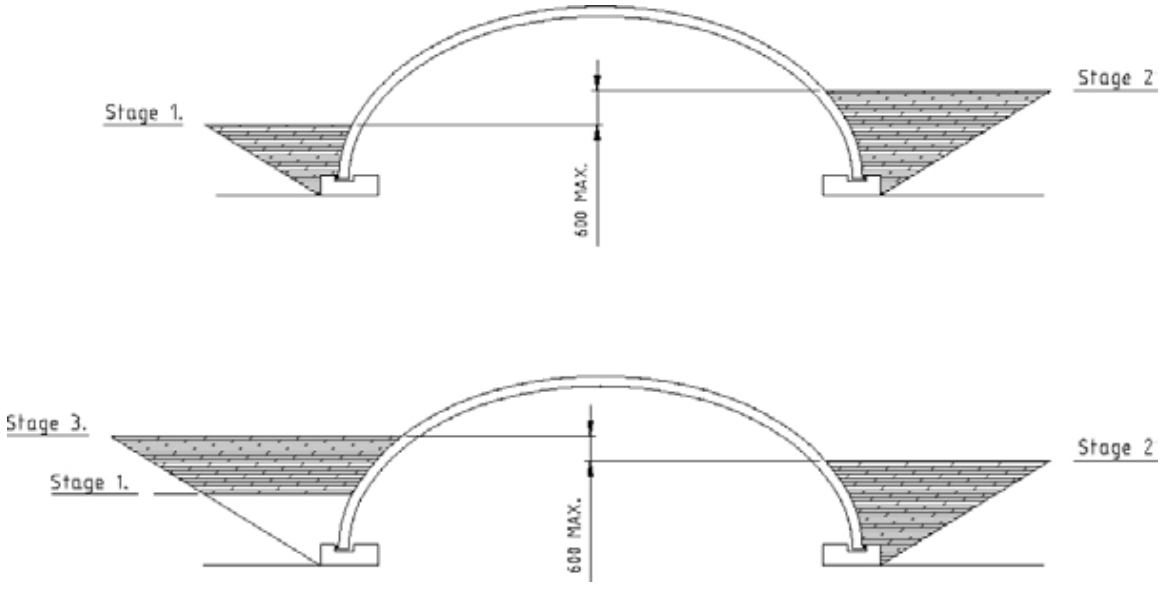
Embedment materials placement

The sidefill and overlay material should be placed in loose layers not exceeding 300 mm so as to achieve the required compaction. Dumping of backfill material is not allowed adjacent to and within the middle third of the arch span until the height of fill over the arch exceeds 1.0 m. See Figure 12 (previous page).

The most critical factor during backfilling is that the maximum difference in the levels of fill on opposite sides must not exceed 600 mm as shown in Figure 13. This difference must alternate from side to side as the fill rises up the arch sides so that the backfill operation induces no permanent sideways movement in the arch.

Lines may be marked on arch units indicating each fill level as a guide to the equipment operators and to ensure that the maximum difference in the levels of fill on opposite sides does not exceed 600 mm.

Figure 13 – Zone B backfill stages



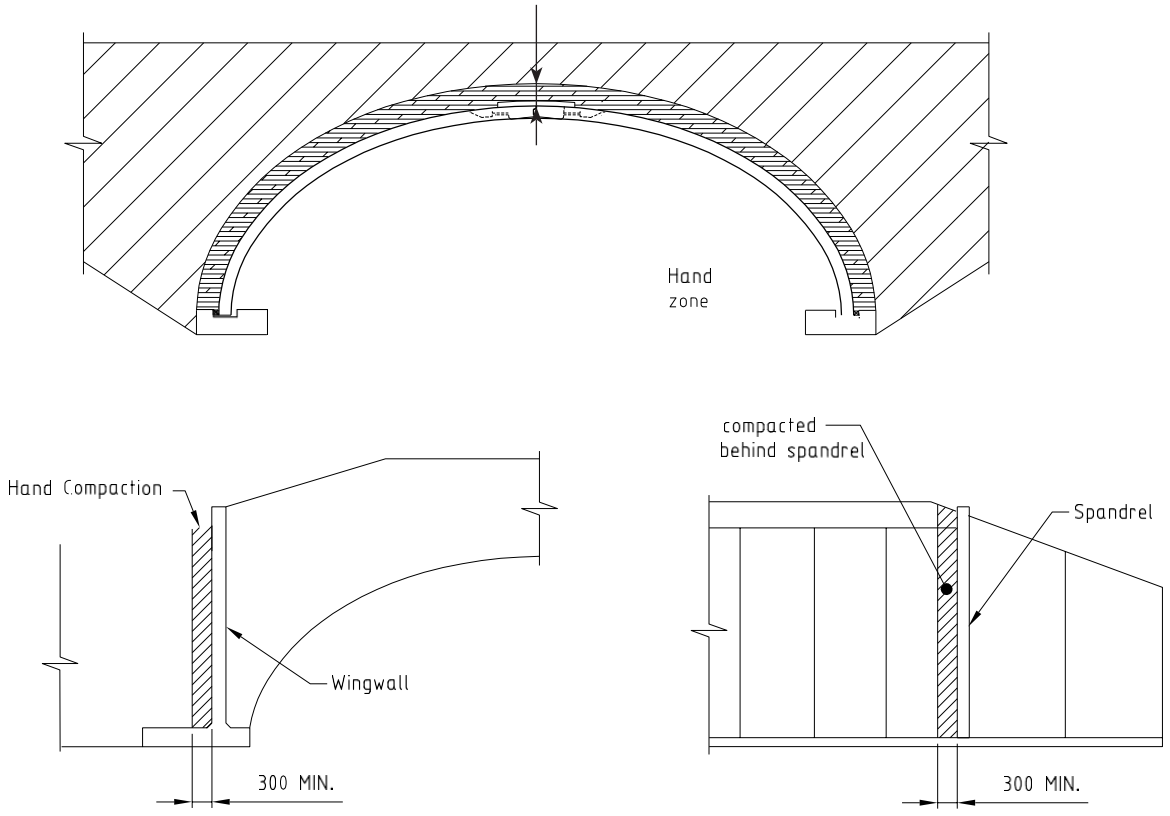
Backfill compaction

Zone B (sidefill) backfill material must be compacted to not less than 95% of the maximum dry density at optimum moisture content for standard compaction.

Zone C (overlay) and Zone D backfill material shall be compacted in accordance with the owner's consulting engineer's project specifications for compacted embankment fill.

To avoid damaging or causing instability of the structure, the backfill material adjacent to the arch and behind the wingwalls and spandrels is hand compacted as shown in Figure 14.

Figure 14 – Hand compaction zones



Restrictions for construction machinery

For the immediate area of the arch, there are restrictionsfor construction machinery as follows:

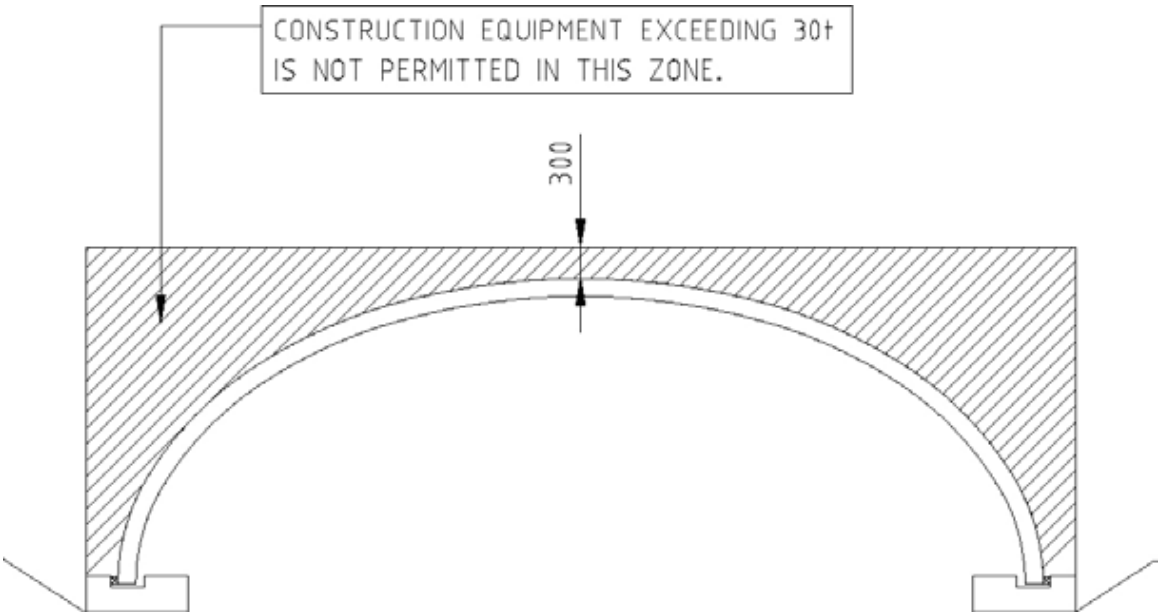
a) The bare arch may not be crossed over by any heavyconstruction equipment.

b) Construction and compaction equipment heavier than10 tonnes is not allowed in the backfill zone indicatedin Figure 22.

c) To avoid excessive vibration in the arch, heavy vibratingcompaction equipment (greater than 5 tonne) should be started and switched off outside the limits as shown for dumping in Figure 19.

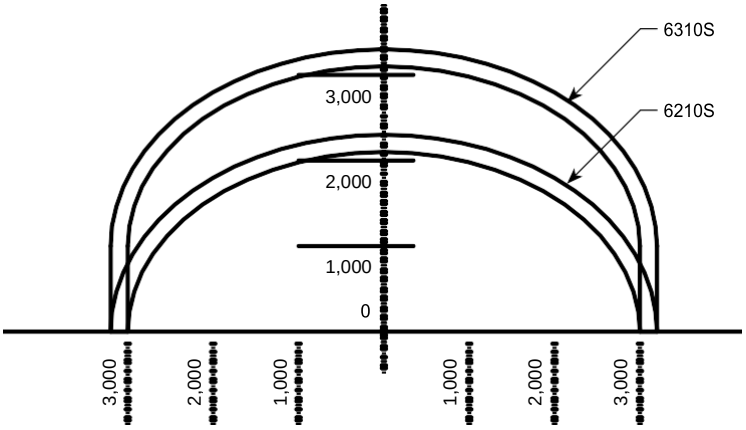
d) After compacted fill has been placed to a height of 500 mm over the crown, construction equipment witha maximum gross vehicle weight of 30 tonnes may cross the arch. If construction equipment with gross vehicle weight greater than 30 tonnes is required to pass over the arch, consult Humes engineers to confirm if this is possible and the minimum fill heightwhich may be required over the top of the arch.

Figure 15 – Restrictions for construction machinery

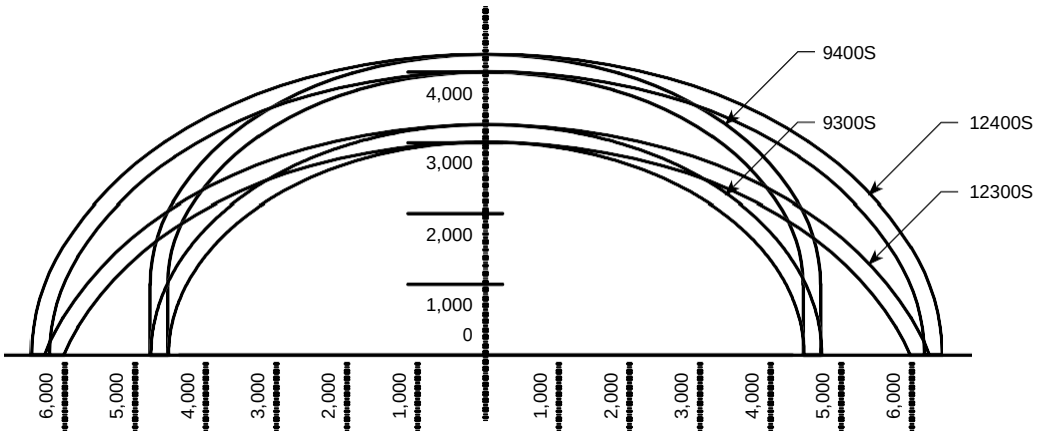


Appendices

Appendix 1 – One piece arch classifications



Classic series



BEBO® series

Appendix 2 – Sample one piece arch shopping list

Date:.....

Project:.....

One piece arch bridge comprising of:

..... off ..... arch units in total, including specials, weighing approx.....tonnes each.

..... off ..... spandrels weighing approx .....tonnes each.

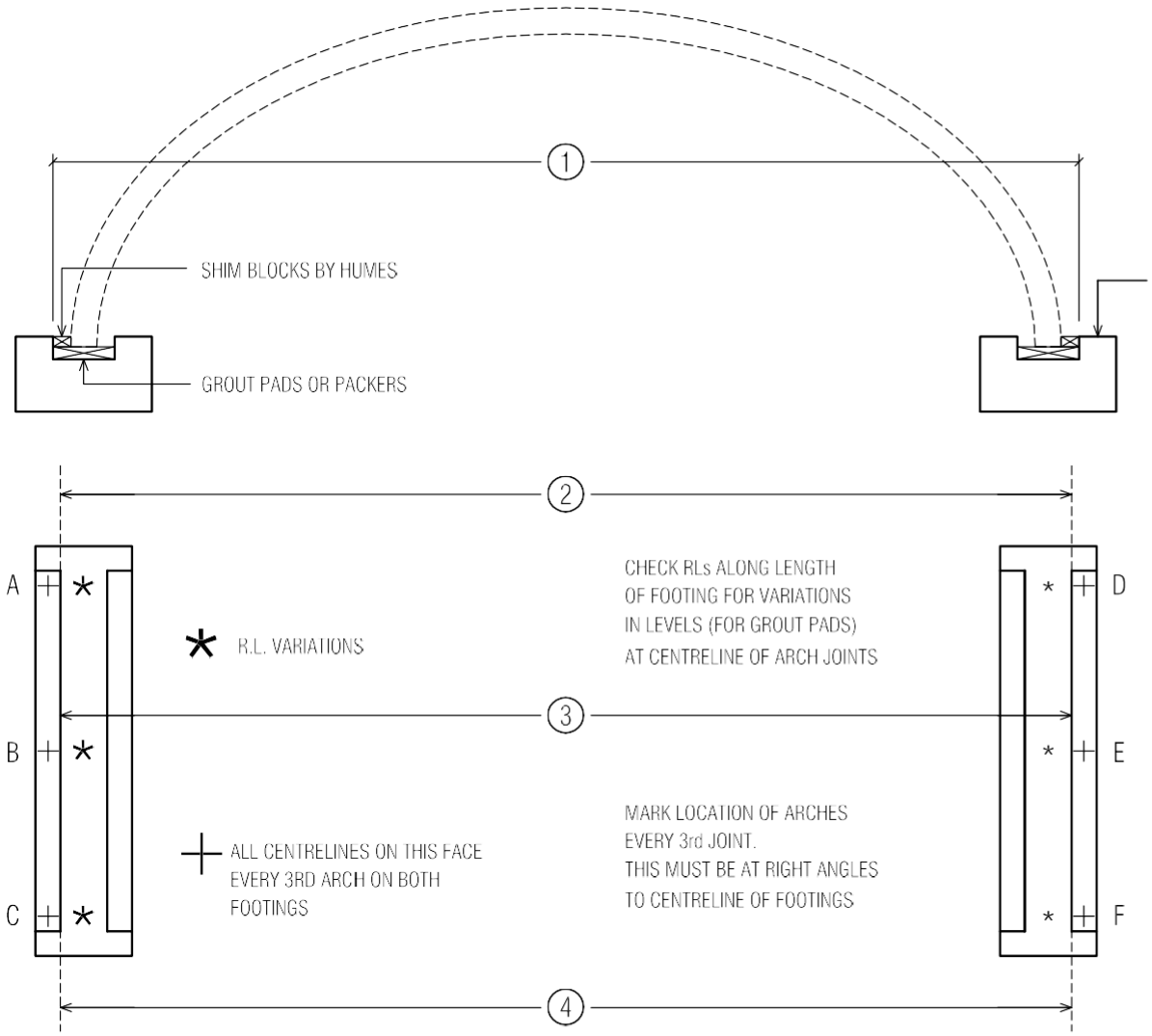
..... off ..... type wingwall weighing approx .....tonnes each.

Requirements	Action
Craneage to be capable of handling arches, spandrels and wingwalls from the trucks, turning them in the air and erecting them in their nominated positions	Customer
All arch units to be delivered to site in a sequence to suit erection.	Customer/Humes
Special sequence and quantities to be programmed into deliveries to suit erection.	Customer/Humes
The spandrels to be delivered and erected directly off the trucks.	Customer/Humes
Arch shim blocks. .....off.	Humes
Unilift locking klaw lifting clutches and appropriate lifting equipment e.g. running snatch blocks for erecting arches (four off) sling lengths for erection of Arch – Long slings ..... mm (including snatch blocks), short slings mm, and for unloading arches – Sling lengths 10,000 - 11,000 mm. • Snatch slings to be minimum of 8,000 mm long overall. • Unilift locking klaw lifting clutches required: ..... off 20 tonne ..... off 10 tonne ..... off 5 tonne	Crane company
Safety harnesses to access the top of the arches.	Crane company
Arch levelling packers set under arches in lieu of concrete pads, packer size is 400 mm x 300 mm to make up packer height of 50 mm using 18 mm and 12 mm compressed sheeting.	Customer
Miscellaneous plastic packers required for erection are 150 mm x 100 mm of varying thickness 2 mm, 5 mm, 10 mm and 20 mm available off the shelf. Initial requirement: .....off 100 pack of 2 mm,. ..... off 100 pack of 5 mm, ...off 50 pack of 10 mm,. ..... off 50 pack of 20 mm.	Customer
Softwood wedges 150 mm long x 75 mm wide x 50 mm thick down to 20 mm. These are used to hold arch bases back against shim blocks during final positioning.	Customer

Requirements	Action
Arch 'joint centrelines' to be marked on the top of the rear face on both sides of the arch footings.	Customer
Stepladders required on site to access lifting knuckles when unloading and unhooking the arches and extension ladders to access the top of the arches during erection.	Customer
Birk bars for adjusting units during erection.	Crane company
Levelling of packers and set out of job prior to erection.	Customer
2 x chain blocks (2-3 tonne) complete with 4-6 m soft slings normally carried by cranes. These are for pulling top arch joints together and/or to level and adjust units as required.	Crane company
Materials and sealing of joints.	Customer
All alignment of arches to be carried out by theodolite, stringline and plumb bob.	Customer
Checking of footings for both parallel and critical width with shim blocks supplied by Humes.	Customer
Necessary hand tools are required to adjust and tighten arch to spandrel tie-back brackets.	Customer
Fitting of spandrel and end arch tie-back fittings to be carried out prior to delivery of these units to site.	Humes
Tail ropes will be required for all units during erection	Crane company
All arch and spandrel unit lifting points to be checked with lifting knuckles before units leave factory.	Humes

Notes

ISSUE	DETAILS OF ALTERATIONS	DWN	DATE	CKD
D	GENERAL REVISIONS	RM	30-01-08	DFW
E	GENERAL REVISIONS	RM	20-03-08	DFW



1. THEORETICAL CRITICAL DIMENSION _____
2. ACTUAL DIMENSION FAR END _____
3. ACTUAL DIMENSION MID POINT _____
4. ACTUAL DIMENSION NEAR END _____
5. RL VARIATIONS:

A	D
B	E
C	F

Humes TECHNICAL (DESIGN) SERVICES
BRISBANE, QUEENSLAND

MARK CENTRELINE OF ARCH JOINTS ON NEAR FACE OF FOOTINGS AS SHOWN, PERPENDICULAR TO BRIDGE CENTRELINE EVERY THIRD ARCH JOINT.

CHECK AND MARK ANY RL VARIATIONS OF FOOTINGS AT ARCH JOINT CENTRELINES.

Humes ABN 87 099 732 297

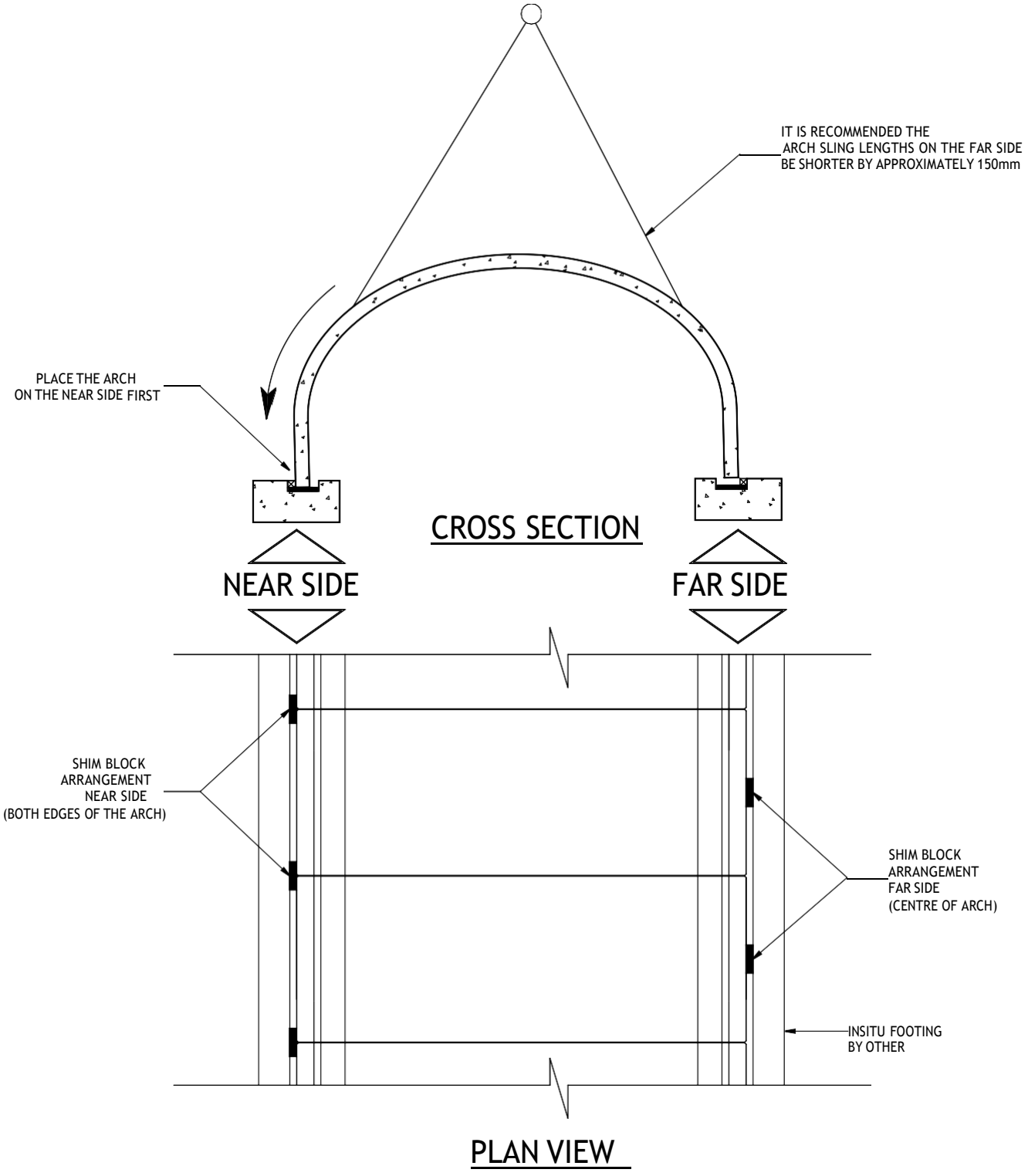
DSN.	RM	30-01-08
DWN.	RM	30-01-08
CKD.	RM	30-01-08
APP.	RM	30-01-08

SUPERSEDES CHK-SHT-01 Issue C

HUMES
ONE PIECE ARCH SYSTEM
PRE-ERECTION CHECKSHEET
CRITICAL DIMENSIONAL REQUIREMENTS

PLOT SCALE	SIZE	DRG. NO.	ISSUE
1:1	A4	CHK-SHT	E

Appendix 4 – Shim block configuration and installation process



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