DESIGN AND CONSTRUCTION OF SEGMENTAL BRIDGES TO ACCOMMODATE FUTURE WIDENING USING THE "STRUTTED BOX WIDENING METHOD"

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ABSTRACT

The "strutted box widening method" (sbwm) allows a 2-lane segmental bridge to be designed and constructed so that it can easily be widened into a 3-lane or 4-lane bridge at any time in the future. This is a unique solution since widening only needs to be done when and if traffic volumes warrant it. The "strutted box widening method" when used in conjunction with high performance materials such as HPC has the potential to satisfy all ten of the FHWA performance objectives for "The Bridge of the Future", and especially satisfies the requirement "easily widened or adaptable to new demands".

Two example problems demonstrate how the "strutted box widening method" can similarly be used to widen a constant depth precast segmental bridge and a variable depth cast-in-place segmental bridge. Widening is accomplished by installing exterior compression struts and pouring additional deck slab. Both longitudinal external prestressing tendons and transverse internal prestressing tendons are installed and stressed. An erection truss which can be used to widen the bridge is introduced, and construction staging during widening is discussed.

The author believes that the "strutted box widening method" should be given serious consideration by government agencies and design/build consortia starting at the planning stage on any project. It is an excellent solution to build an economic and efficient bridge to handle current traffic volumes, while at the same time planning ahead to build cost effective and schedule effective bridge widenings to handle future traffic volumes.

Keywords: Analysis, Balanced Cantilever Erection, Box Girders, Bridges, Construction, Design (Structural), Precast Concrete, Prestressed Concrete, Post-Tensioning, Research, Span-By-Span Erection, Segmental Bridges

INTRODUCTION

The "strutted box widening method" (sbwm) is introduced in this paper for the widening of prestressed concrete segmental bridges. The method allows a 2-lane segmental bridge to be designed and constructed so that it can easily be widened into a 3-lane or 4-lane bridge at any time in the future. This is a unique solution since widening only needs to be done when and if traffic volumes warrant it. The "strutted box widening method" when used in conjunction with high performance materials such as HPC has the potential to satisfy all ten of the FHWA performance objectives[1] for "The Bridge of the Future". It readily satisfies the requirement "easily widened or adaptable to new demands".

The "strutted box widening method" was invented by the author[*], and has been implemented by the author on the design of the concrete alternate for the North Saskatchewan River Bridge[2] in Edmonton, Canada. Although the successful low bid by Kiewit was for the steel alternate, representatives of Kiewit have indicated to the author that their bid prices for the concrete and steel alternates were very close. This is especially encouraging because the owner requested that the bids be based on the initial cost only, and not the widening costs or the life-cycle costs. The conclusion is that if the concrete alternate can be competitive with the steel alternate based on initial cost, it will have a significant advantage over the steel alternate when widening costs and life-cycle costs are considered.

The organization of the paper takes the following form. Two example problems present the "strutted box widening method" in detail. The first example is a constant depth precast segmental bridge, while the second example is a variable depth cast-in-place segmental bridge. Advantages and disadvantages of the "strutted box widening method" are discussed. The section on constructibility introduces an erection truss which can be used to widen the bridge, and also discusses construction staging during widening. A detailed discussion is included on how the "strutted box widening method" can satisfy all ten of the FHWA performance objectives for "The Bridge of the Future". The section on "The Urban Solution" discusses how the method can be applied to construct long median based expressways in congested urban environments where right-of-way acquisition is prohibitive. The "strutted girder widening method" (sgwm) which applies to the widening of precast concrete girder bridges, is introduced as a variation to the "strutted box widening method" (sbwm).

The reader is encouraged to consult Reference 2 which gives much more detailed information on the design and analysis of the two example problems given in this paper.

[*] Although strutted boxes have been widely used in the past as solutions for both segmental bridges and cable-stayed bridges, this represents the first time that the strutted box solution has been used as the basis for the future widening of a segmental bridge.

CONSTANT DEPTH SEGMENTAL BRIDGE (EXAMPLE 1)

A six-span constant depth precast segmental bridge built by the balanced cantilever method of construction is considered (Figures 1 and 2). The interior spans are 60m while the exterior spans are 42m, giving an overall length of bridge of 324m. Let us define three stages of construction (Figure 2) and arbitrarily assign dates to these stages of construction:

Stage 1 - 2-lanes plus shoulders - Year 2003
Stage 2 - 3-lanes plus shoulders - Year 2020
Stage 3 - 4-lanes plus shoulders - Year 2060

Thus, the bridge will initially be constructed to have 2-lanes plus shoulders in Year 2003. The intention is to widen to 3-lanes plus shoulders in Year 2020 as traffic volumes increase. Further widening to 4-lanes lanes plus shoulders will occur in Year 2060 as traffic volumes continue to increase. This gives a deck width of 13.8m in Stage 1, 17.5m in Stage 2 and 21.7m in Stage 3.

What makes the "strutted box widening method" such a unique solution is that it is completely flexible. Widening only needs to be done when traffic volumes warrant it. If the traffic volumes do not increase as fast as projected, widening can be delayed indefinitely or as long as necessary. If the traffic volumes increase faster than expected, the bridge can be widened from 2-lanes to 4-lanes directly (it is not necessary to ever have a 3-lane bridge). Assuming that the bridge has a one hundred year life, the final configuration of the bridge after one hundred years can be 2-lanes, 3-lanes or 4-lanes.

The "strutted box widening method" in essence is quite simple (Figure 2). When going from Stage 1 to Stage 2 construction, exterior compression struts are installed and the deck slab is widened. Additional transverse internal prestressing tendons and longitudinal external prestressing tendons are installed and stressed. Widening from Stage 2 to Stage 3 construction is similar. The deck slab is again extended (cantilevered), and additional transverse internal prestressing tendons and longitudinal external prestressing tendons are installed and stressed.

The compression struts can consist of either 0.400m by 0.400m precast concrete elements or 0.324m diameter steel pipes with end plates, that frame into concrete buildouts (blisters) and transfer the load directly to the bottom slab from triangular shaped exterior longitudinal T-beams at the deck level. The compression struts are spaced at 3.6m along the length of the bridge. In order for the compression struts to be effective, they need to have an angle with the deck surface of at least 30^o. This means that the section depth may be governed by the compression strut geometry rather than the span/depth ratio. In this case, the section depth is 3.2m which gives a strut angle of 33^o and a span/depth ratio of 18.8. The section depth is thus governed here by the compression strut geometry rather than the span/depth ratio.

The segment layout is shown in Figure 3. Each balanced cantilever has a 1.8m pier segment and eight 3.6m typical segments on each side of the cantilever. Closure segments are 0.6m. The end spans have a 1.5m abutment segment and three 3.6m typical segments which are assembled on falsework. The construction sequence is to proceed from one end of the bridge to the other, building cantilevers P1 to P5 in succession, and pouring closures in the backspan as construction proceeds. At the completion of construction, the bridge is on fixed bearings at P3 and expansion bearings everywhere else (see Figure 1).

Figures 3 and 4 show the external tendon layout and bulkhead details. Stage 2 construction requires two 15 strand tendons in the interior spans and two 9 strand tendons in the exterior spans. Similarly, Stage 3 construction requires two 15 strand tendons in the interior spans and two 9 strand tendons in the exterior spans. These draped tendons are held down at the deviation diaphragms and anchored at the pier/abutment diaphragms. Figure 4 shows the disposition of all prestressing in the bulkhead. There are 14 cantilever tendons per web near the pier and 6 bottom span tendons per web near midspan which are anchored in the anchor blocks. The draped external tendons are at the bottom of the section near midspan and at the top of the section near the pier. Finally, there is provision for future contingency tendons. An open cellular abutment facilitates the anchorage of future tendons as well as external tendons.

Figure 5 shows the transverse prestressing tendon layout in plan and section for the three stages of construction. Each tendon consists of four strands in a flat duct. There are twelve transverse prestressing tendons in each segment. Three tendons are stressed in Stage 1, three tendons are stressed in Stage 2 and six tendons are stressed in Stage 3. The tendon profile is at the top of the deck near the web for negative moment, and in the middle of the deck near midspan for both positive and negative moment. The transverse prestressing shown in Figure 5 represents a minimum amount. The deck can have additional transverse compression by replacing tendons at each stage of construction. Thus, additional Stage 1 tendons could be used and these tendons would be removed in Stage 2 and replaced with longer Stage 2 tendons. Additional Stage 2 and Stage 3 tendons could be used and replaced in a similar way. The number of tendons at each stage of construction can thus be optimized.

The transverse prestressing ducts for the Stage 2 and Stage 3 widenings need to be installed during Stage 1 (or Stage 2) construction. These plastic ducts need to be protected against moisture intrusion which can lead to freezing and cracking of the deck concrete. One suggestion is to fill the ducts with grease or foam and cap the ends. The grease or foam would be flushed out when widening occurs. Another suggestion is to place continuous foam backer rod in the empty ducts for the entire length of each tendon and cap the ends. Freezing water would simply compress the backer rod and not crack the concrete. The backer rod would be removed when widening occurs. At any rate, protection of ducts for Stage 2 and Stage 3 widenings is very important for the durability of the structure. If tendons are to be replaced when widening occurs, the unbonded tendons will have to be destressed and removed, the ducts will have to be cleaned of all grease and foreign material, and new strand and anchorages will have to be installed, stressed and grouted.

Figure 6 shows the deck drainage details for the three stages of construction. The Stage 1 scuppers are located to avoid both the longitudinal and transverse tendon ducts. The deck drain pipes dump water into an open hopper collector pipe. In going from Stage 1 to Stage 3, the size of the scuppers and drain pipes increases, since the volume of water to be drained increases as the deck area increases. The Stage 1 and Stage 2 scuppers are abandoned in place by removing the grating and carefully concreting the remainder of the scupper.

Figure 6 also shows that the barrier curbs have to be relocated for each stage of construction. It is suggested that stainless steel dowels be used to attach the barrier curbs to the deck. The dowels can be cut flush with the deck at the time of widening, and there will not be any corrodeable reinforcing near the deck surface.

It is suggested that interior lighting be installed inside the box girder during Stage 1 construction. The lighting consists of ceiling mounted luminaires and wall mounted duplex receptacles at a 10-15m spacing for the length of the bridge, connected to a power distribution panelboard located in the abutment cell. A portable generator is brought in to provide power for the duration of all inspection and maintenance activities, as well as during installation and stressing of longitudinal external prestressing tendons for Stage 2 and Stage 3 construction.

VARIABLE DEPTH SEGMENTAL BRIDGE (EXAMPLE 2)

A three-span variable depth cast-in-place segmental bridge[*] built by the balanced cantilever method of construction is considered (Figures 7 and 8). The main span is 160m while the end spans are 100m, giving an overall length of bridge of 360m. The depth of the section (Figure 8) varies from 9.0m at the pier to 3.6m at midspan, which gives span/depth ratios of 17.8 and 44.4 at the pier and midspan respectively. The strut angle is 39^o in this example.

The bridge (Figure 8) has 2-lanes plus shoulders in Stage 1, 3-lanes plus shoulders in Stage 2 and 4-lanes plus shoulders in Stage 3. This gives a deck width of 13.8m in Stage 1, 17.5m in Stage 2 and 21.7m in Stage 3. As before, widening from Stage 1 to Stage 2 is accomplished by installing exterior compression struts and pouring additional deck slab. Both transverse internal prestressing tendons and longitudinal external prestressing tendons are installed and stressed. Widening from Stage 2 to Stage 3 is accomplished by again pouring additional deck slab, and installing and stressing additional transverse internal prestressing tendons and longitudinal external prestressing tendons.

Although the lane configurations and widening procedure are identical for both the variable depth bridge (Figure 8) and the constant depth bridge (Figure 2), there is a difference in the structural load transfer system. A variable depth bridge (Figure 8) has all compression struts

[*] The only reason that a cast-in-place segmental bridge is considered here is because the span lengths are outside the range of those considered for a precast segmental bridge. The material presented in this section applies equally to a variable depth precast segmental bridge.

at the same distance from and the same angle to the deck surface. This means that interior compression struts are required to balance the exterior compression struts. This also means that web bending will occur due to unbalanced live load. [Note that the interior compression struts have been shown to be installed in Stage 1 when access during balanced cantilever construction is possible, although they are not actually activated until Stage 2.] A constant depth bridge (Figure 2) does not require interior compression struts since the force in the exterior compression struts is transferred through the bottom slab and taken in torsion. Hence, a constant depth bridge is structurally more efficient and easier to design than a variable depth bridge. However, both are still very good structural solutions.

The compression struts can consist of either 0.400m by 0.400m precast concrete elements or 0.324m diameter steel pipes with end plates, that frame into concrete buildouts (blisters) and transfer the load directly to the webs from longitudinal beams at the deck level. Note that there are two triangular shaped exterior longitudinal T-beams and one rectangular shaped interior longitudinal T-beam. The compression struts are spaced at 5.0m along the length of the bridge.

The segment layout is shown in Figure 9. Constrained by the form-traveler lifting capacity on one hand and the desire to minimize the total number of segments on the other, 5.0m-long segments have been chosen. A one-half segment unbalance is built into the pier table (6.0m vs 8.5m) to minimize the unbalanced moment which is transferred into the pier and foundation. Hence, there are 15 and 14 cantilever segments respectively on each side of the cantilever. There is a 5.0m abutment segment, two 5.0m segments which have to be constructed on falsework and a 5.0m closure segment in the end span. Finally, there is a 3.0m closure segment in the main span which is cast to complete construction of the bridge.

Figures 9 and 10 show the external tendon layout and bulkhead details. Four 25 strand tendons are required for Stage 2 construction and four 25 strand tendons are required for Stage 3 construction. These straight tendons pass freely within the box and are anchored in the abutment diaphragm. Anti-vibration devices are required for these simple 360m long tendons which have no friction losses. Figure 6 shows the disposition of all prestressing in the bulkhead. It is worthwhile to briefly describe the prestressing because the strutted box is not overly congested despite the fact that there is a substantial amount of prestressing. There are 30 cantilever tendons per web near the pier corresponding to the 29 segments plus pier table being cantilevered. There are 16 bottom span tendons per web near midspan which are anchored in pairs in anchor blocks at the strut locations. There are 6 continuity tendons per web which are anchored in pier/abutment diaphragms. The continuity tendons are in a single row near the pier for shear reasons and in two rows near midspan to maximize the eccentricity. The external tendons pass freely within the box as can be seen in the section at the pier and midspan. Finally, there is provision for future contingency tendons. Again, an open cellular abutment facilitates the anchorage of future tendons as well external tendons.

The transverse tendon details for the variable depth cast-in-place segmental bridge are similar to those for the constant depth precast segmental bridge (Figure 5).

ADVANTAGES AND DISADVANTAGES OF THE SBWM

The "strutted box widening method" has a great number of advantages. These are discussed throughout the paper and summarized in the section entitled "The Bridge of the Future". There are also a few things to keep in mind when designing a bridge which may, or may not, be widened twice during its lifetime:

(1) The design effort is increased because the designer has to design for three stages of construction. By keeping the design for each stage of construction independent from one another as outlined in Reference 2, the additional amount of design work is not that great.
(2) The foundations and piers have to be designed to support the Stage 3 service loads. Since balanced cantilever construction requires increased substructure capacity for unbalanced moments, there should already be adequate load capacity for the Stage 3 service loads.
(3) The shear reinforcement has to be designed to support the Stage 3 service loads. There is no way to get around this. For the two examples given here, the shear capacity required to achieve a 200% increase in traffic capacity varies from 118% for the variable depth bridge to 127% for the constant depth bridge. No increase in flexural capacity is required. Longitudinal external tendons are installed and stressed in Stage 2 or Stage 3 as they are required (although provision for deviation and anchorage has to be provided in Stage 1). Similarly, transverse prestressing is installed and stressed as it is required.

CONSTRUCTIBILITY

This erection truss shown in Figure 11 can be used to widen the bridge directly from 2-lanes to 4-lanes (Stage 2 and Stage 3 construction combined) as shown. This versatile truss can also be used to widen from 2-lanes to 3-lanes (Stage 2 construction) or from 3-lanes to 4-lanes (Stage 3 construction). The erection truss serves several purposes. First, it facilitates the erection of the exterior compression struts. Next, it allows the concrete deck to be formed and poured. Finally, it gives a working platform for the transverse prestressing to be installed and stressed. The truss bears over the webs and has suspended forms at the ends for the Stage 2 and/or Stage 3 concrete deck pours. The ends of the truss have safety rails as well as extra room for stressing the transverse prestressing. The truss bears on Hilman rollers which are locked during the concrete pour and then freed to allow the truss to advance. A staggered pouring sequence similar to that for a composite steel girder bridge is used.

Let us look at the construction staging (Figure 12) for expanding twin 2-lane bridges into twin 4-lane bridges. Step 1 shows twin 2-lane bridges. Step 2 shows the westbound bridge being widened after its traffic has been diverted onto the eastbound bridge. Step 3 shows the eastbound bridge being widened after all traffic has been diverted back onto the westbound bridge. Step 4 shows twin 4-lane bridges. Step 2 is the critical stage for traffic management. Here, the choices are (1) to have two narrow lanes each way (as shown), (2) to have one-lane each way with a reversible middle lane, or (3) to close the westbound bridge temporarily and divert traffic to some other location in the transportation system.

"THE BRIDGE OF THE FUTURE"

The "strutted box widening method" when used in conjunction with high performance materials such as HPC has the potential to satisfy all ten of the FHWA performance objectives[1] for "The Bridge of the Future":

- Easily widened or adaptable to new demands - By anticipating possible future widening during the planning and design stages for any project, a bridge can economically be designed for present traffic conditions, while having the flexibility to be widened twice during the life of the structure.

- Lateral clearance greatly increased with longer spans - Segmental bridges can be built economically to have very long spans as well as shorter spans normally associated with steel and concrete girder bridges. The sbwm applies in the same way to longer span variable depth bridges and shorter span constant depth bridges.

- Vertical clearance increased with shallower structures - Variable depth segmental bridges can have very shallow depths at midspan. Constant depth segmental bridges can have shallow depths as well, as long as the angle of the compression struts with respect to the deck surface is reasonable.

- Immunity to flooding, earthquakes, fire, wind, fracture, corrosion, overloads, and vessel collision - Segmental bridges are presently being built to satisfy all these criteria.

- Constructibility to be as important as durability - Both durability and constructibility are extremely important. Durability is ensured by having factory produced precast segments utilizing high-strength concrete with appropriate additives along with the latest in reinforcement. Constructibility is ensured by using the erection truss shown in Figure 11 along with the construction staging shown in Figure 12. These allow the cost effective and schedule effective doubling of traffic capacity by widening rather than twinning.

- A fraction of the current construction time - The segmental bridges discussed in this paper can be widened in six months to double the traffic capacity, while twinning these bridges would take more than two years. Equally as important is that the construction cost of widening the bridges is a fraction of that for twinning the bridges. This has to be extremely attractive to government agencies who are under increasing pressure to make their construction budgets go further. This will make sense to taxpayers who will not question why a 4-lane bridge has been built today when hardly enough traffic exists for a 2-lane bridge. This also has to appeal to design/build consortia where financing becomes so important. Why not pay for easily expanding the capacity of a bridge when it is required in 20 or 60 years rather than today?

- Design for easy inspection and maintenance - “Snoopers” allow easy inspection and maintenance of segmental bridges while allowing traffic to pass. The erection trusses introduced here allow even more intensive inspection and maintenance when there is no traffic on the bridge. The use of interior lighting facilitates easy inspection and maintenance inside the box girder for the life of the structure.

- 100-year service life with minimal maintenance - It is now common practice to design segmental bridges for at least a 100-year service life. It is also a common practice for designers of segmental bridges to write an inspection and maintenance manual that suggests to owners what activities should be conducted at various times during the life of the structure. The use of high performance materials such as HPC along with an ongoing inspection and maintenance program will go a long way to ensure that the 100-year service life can be met and exceeded with minimum maintenance.

- Life-cycle costs, inclusive of user costs, at a fraction of current bridges - This is where the method becomes attractive. The life-cycle costs include the initial construction cost, the widening construction costs, the inspection and maintenance costs, the traffic management costs and the traffic user delay costs. The initial construction cost has been shown to be competitive with other bridge systems that do not have the capability to be widened (ie. the concrete bid versus the steel bid for the North Saskatchewan River bridge). The widening costs are a fraction of the twinning costs. Maintenance costs are kept to a minimum by having a regular inspection and maintenance program and by using high performance materials such as HPC. Traffic management costs for widening are greatly reduced from those for twinning (Figure 12). Equally as important, traffic user delay costs are reduced by widening rather than twinning (ie. widened bridges can be opened in six months rather than two years for the twinned bridges).

- Entire bridge from foundations to parapet designed and constructed as a system - This is another area where the method becomes attractive. The method essentially allows the entire bridge from the superstructure to the parapet to be designed and constructed as a system. The sbwm is the same for constant depth bridges (Figure 2) and variable depth bridges (Figure 8). The standardization of the lane and shoulder dimensions for all 2-lane bridges, 3-lane bridges and 4-lane bridges allows the erection trusses (Figure 11) to be standardized so that they can be reused on any segmental widening project (the distance between webs also has to be standardized). There is no capital investment for each new widening project; the builder either already owns or leases the erection trusses for the next widening project.

The “strutted box widening method” not only has the potential to satisfy all ten performance objectives, but the list of objectives can be viewed as a list of advantages when the sbwm is applied to the construction and widening of segmental concrete bridges using high performance materials.

"THE URBAN SOLUTION"

The "strutted box widening method" allows very long portions of elevated median based expressways to be constructed in congested urban environments where right-of-way acquisition is prohibitive. The elevated structure can be constructed and widened in the future as discussed in this paper, or can be constructed directly to its ultimate configuration (3-lanes or 4-lanes). The "strutted box widening method" allows a very wide elevated superstructure (21.7m) to be constructed while having a fairly small substructure footprint in the median. In addition, construction and widening can proceed without disrupting existing at-grade traffic.

WIDENING PRECAST CONCRETE GIRDER BRIDGES

The "strutted girder widening method" (sgwm) is a variation of the "strutted box widening method" (sbwm) that applies to the widening of precast concrete girder bridges. Widening to add one additional lane can be accomplished by installing exterior compression struts and pouring additional deck slab. Both transverse internal prestressing tendons and longitudinal external prestressing tendons can be installed and stressed.

The additional deck slab is partially cantilevered and partially supported by the compression struts. The maximum width that can be supported by the compression struts is governed by the precast girder depth and the desire to have a compression strut angle of at least 30^{o} with the deck surface. The use of transverse prestressing requires that ducts be placed in the deck and protected until widening occurs. The use of longitudinal prestressing requires that hardware be provided to deviate and anchor tendons when widening occurs.

CONCLUSIONS

The author believes that the "strutted box widening method" should be given serious consideration by government agencies and design/build consortia starting at the planning stage on any project. It is an excellent solution to build an economic and efficient bridge to handle current traffic volumes, while at the same time planning ahead to build cost effective and schedule effective bridge widenings to handle future traffic volumes.

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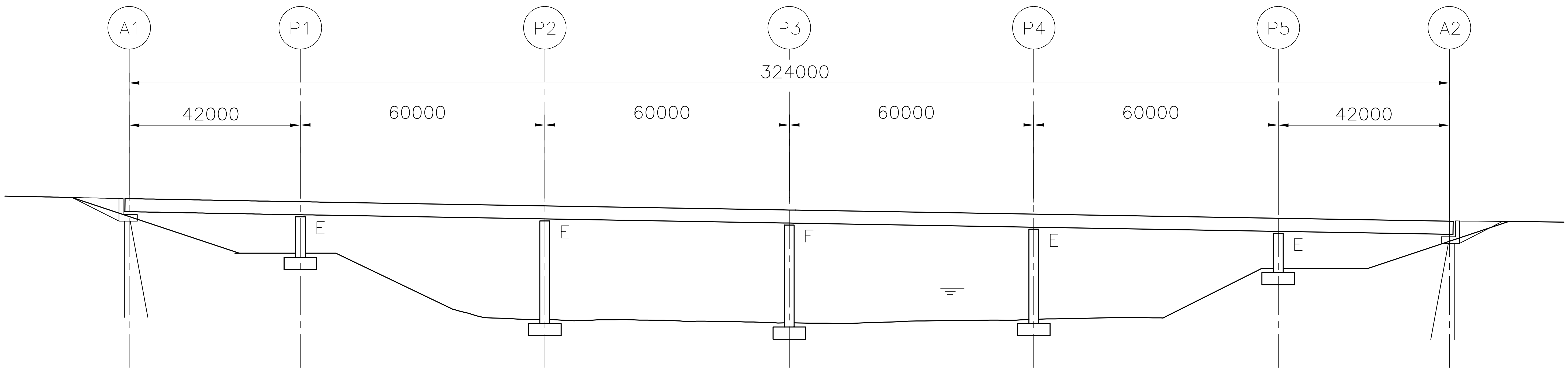
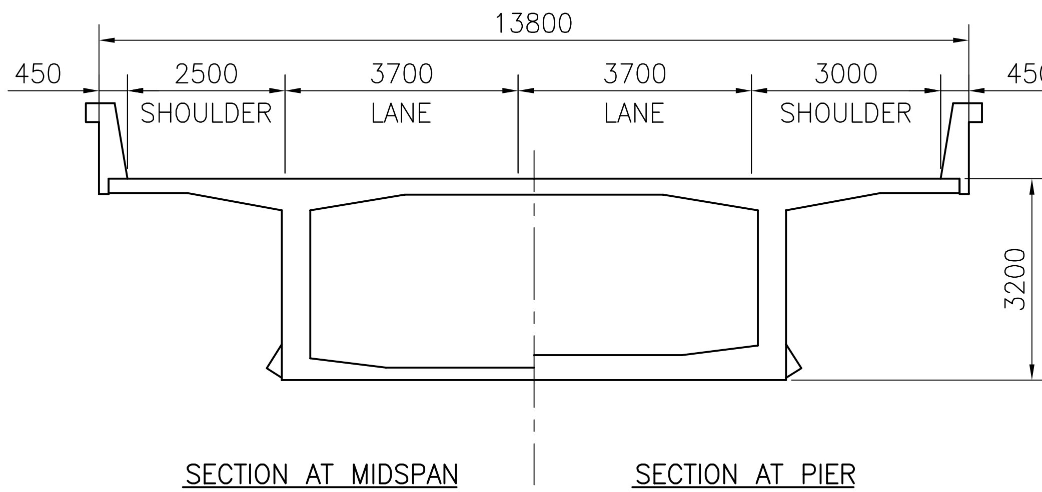
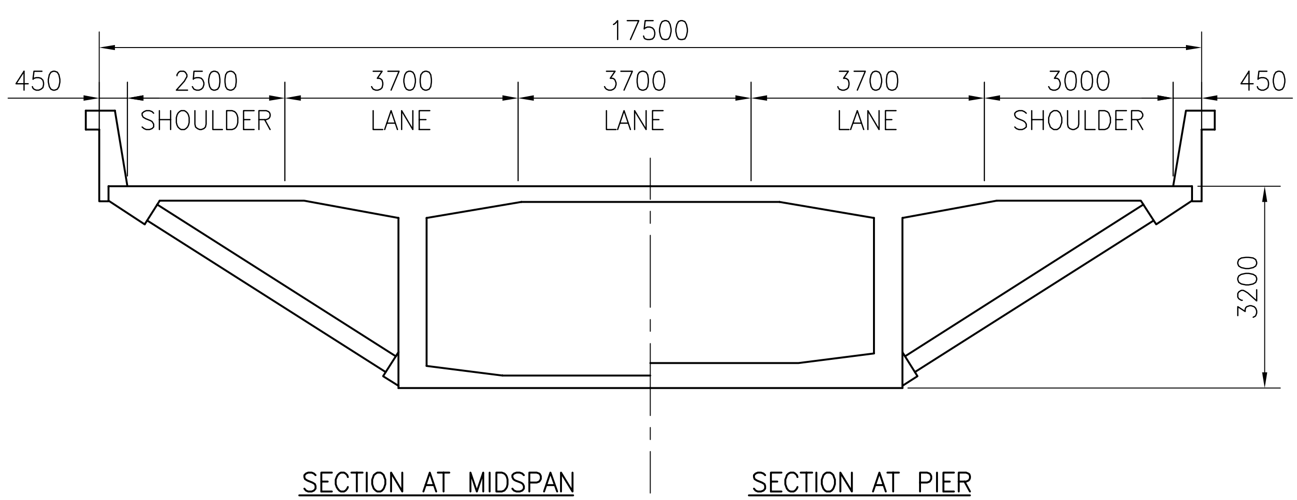


BRIDGE ELEVATION

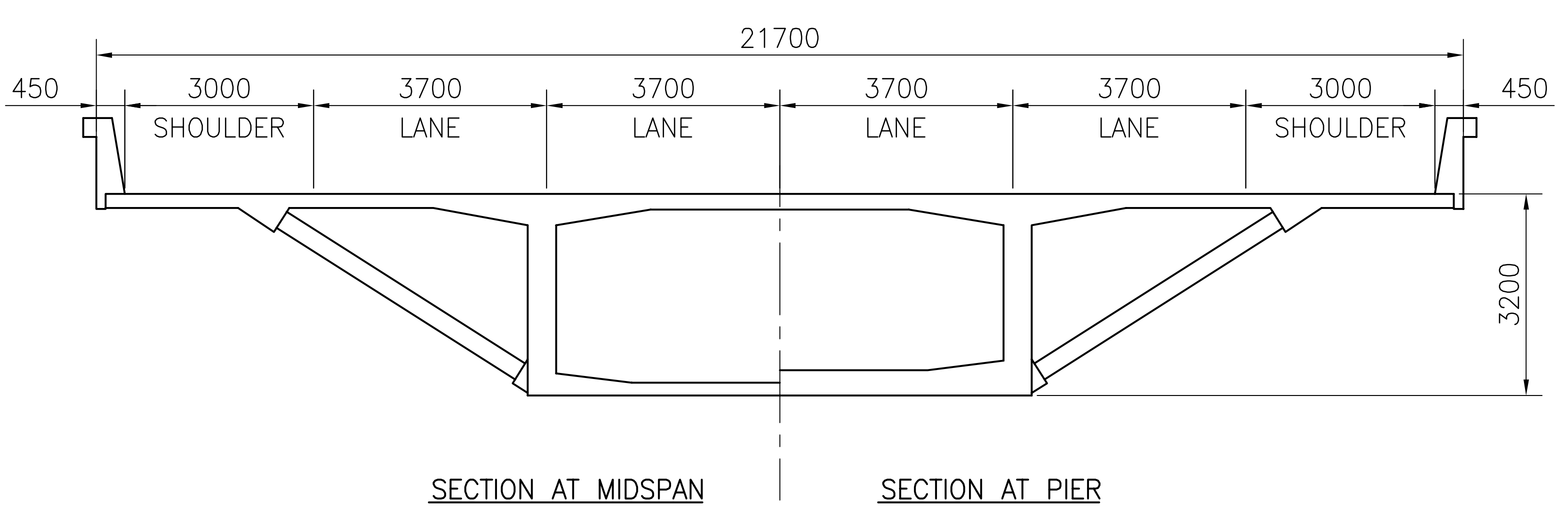
1:1000



STAGE 1 – 2 LANES IN YEAR 2003



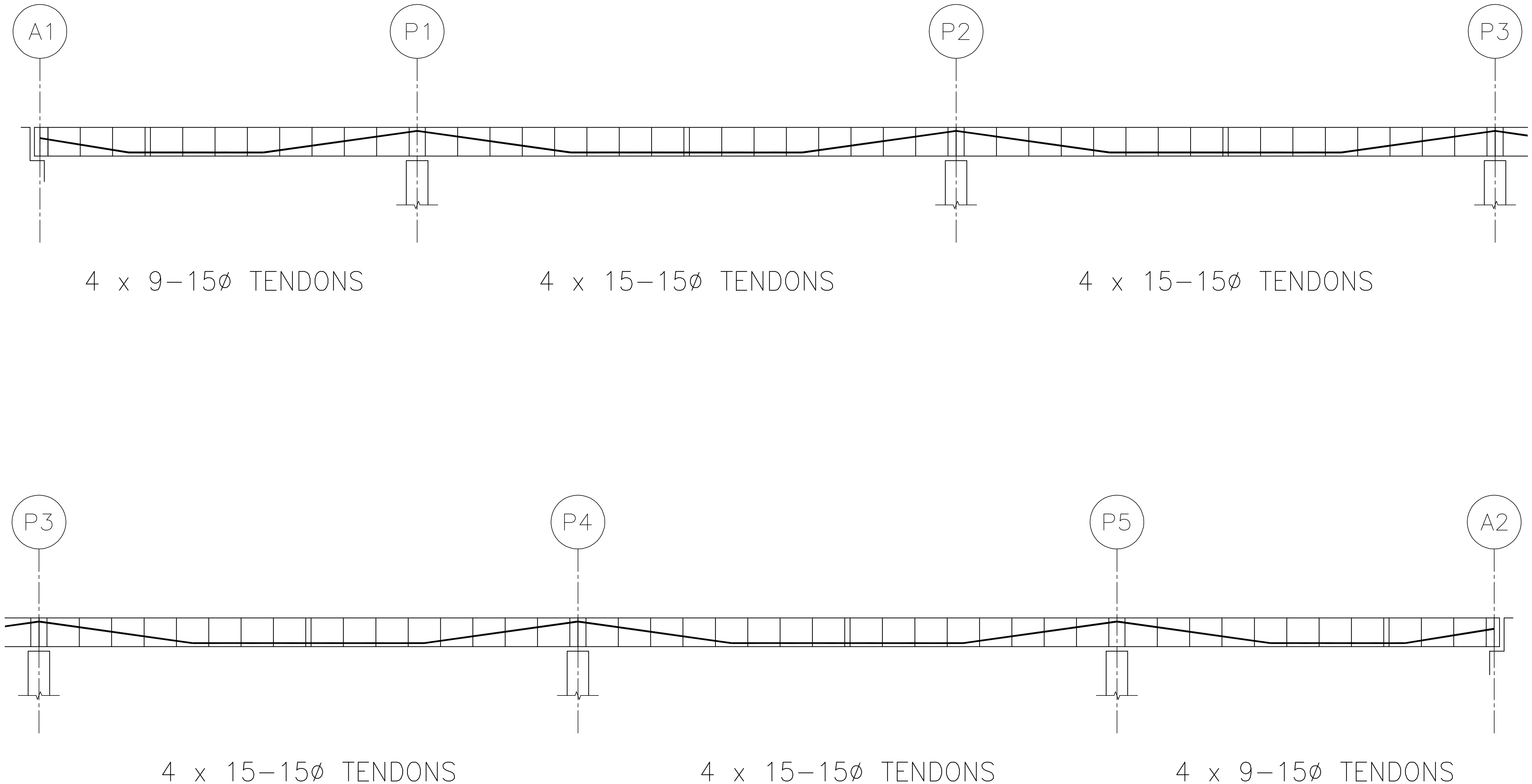
STAGE 2 – 3 LANES IN YEAR 2020



STAGE 3 – 4 LANES IN YEAR 2060

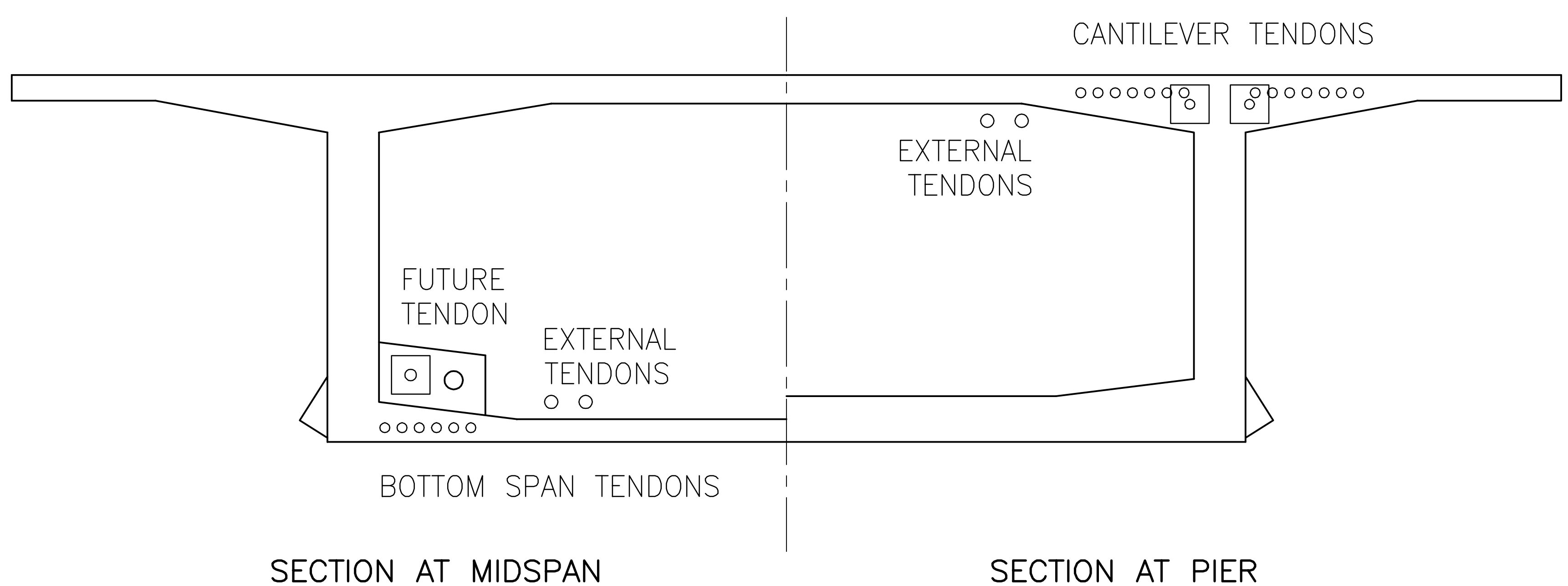
CROSS SECTION WIDENING

1:120



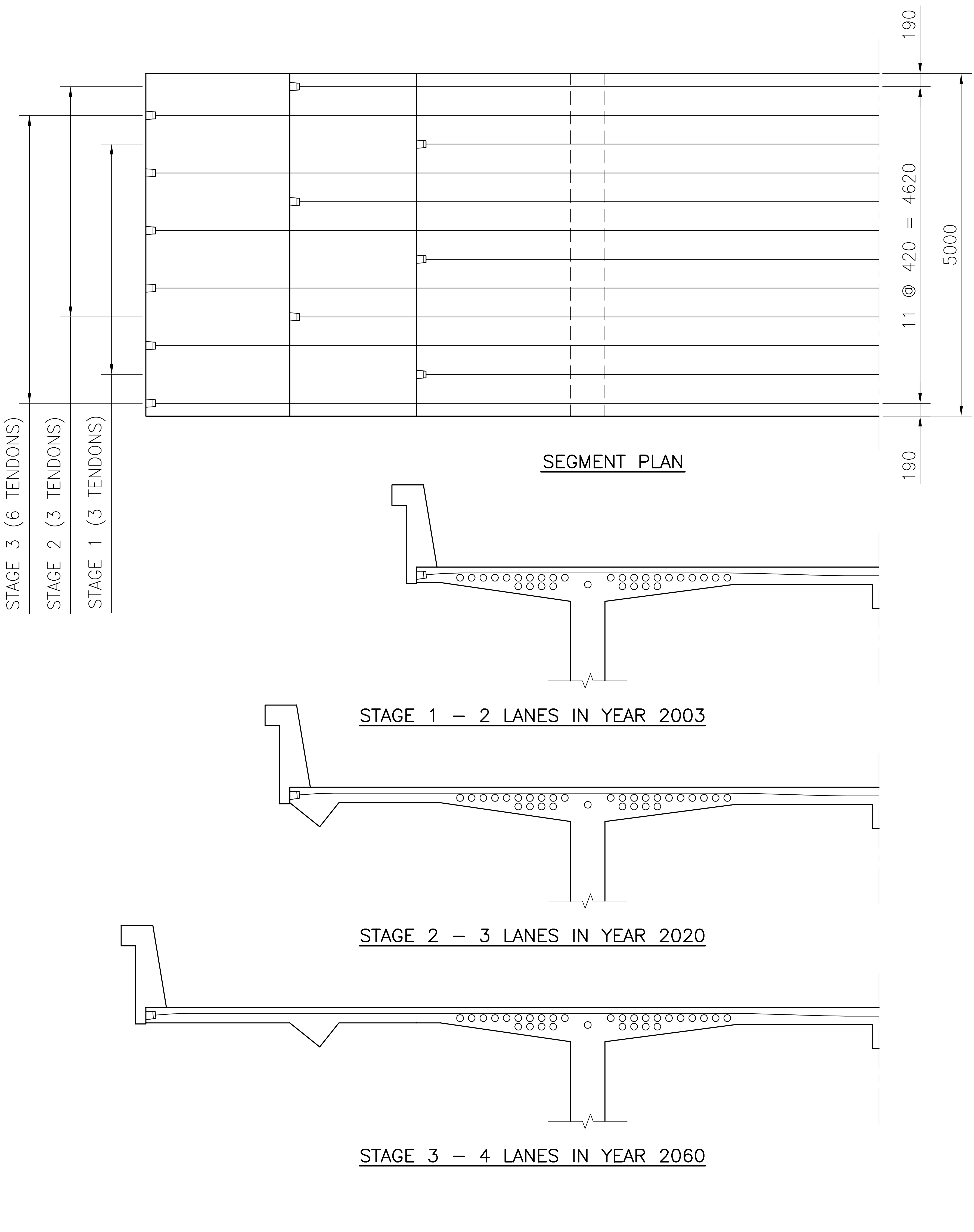
EXTERNAL TENDON LAYOUT

1:500



BULKHEAD DETAILS

1:60



TRANSVERSE TENDON DETAILS

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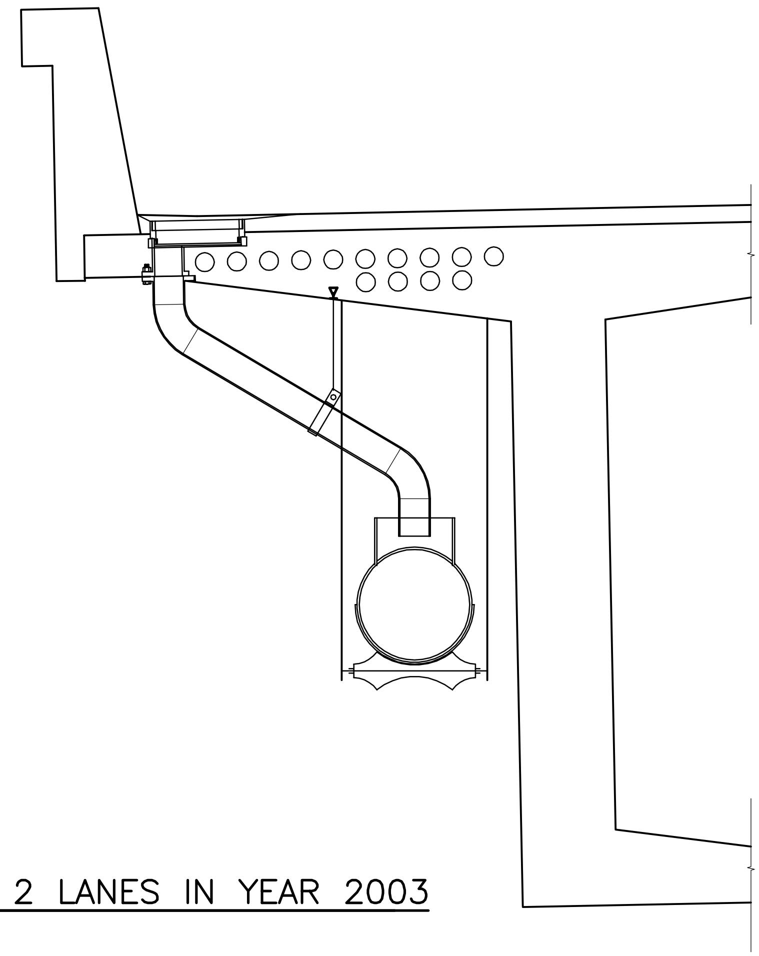
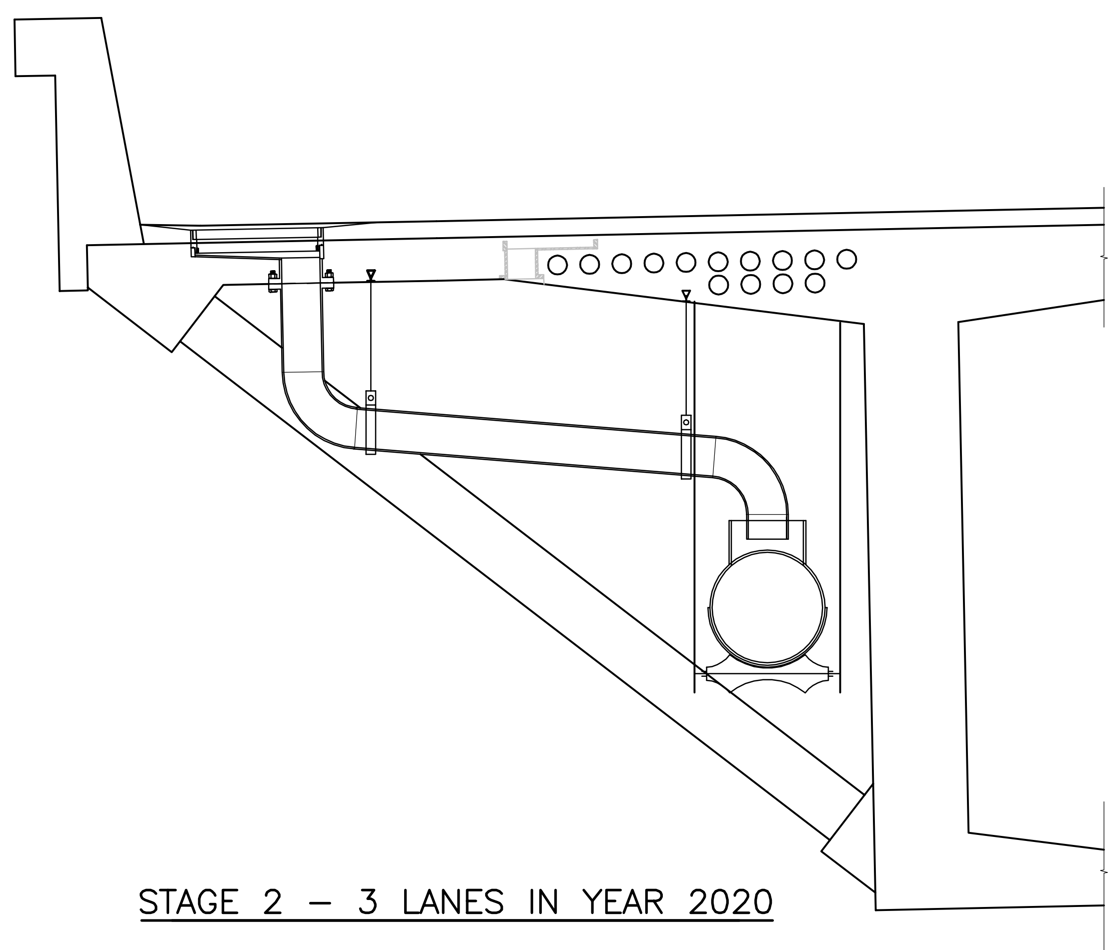
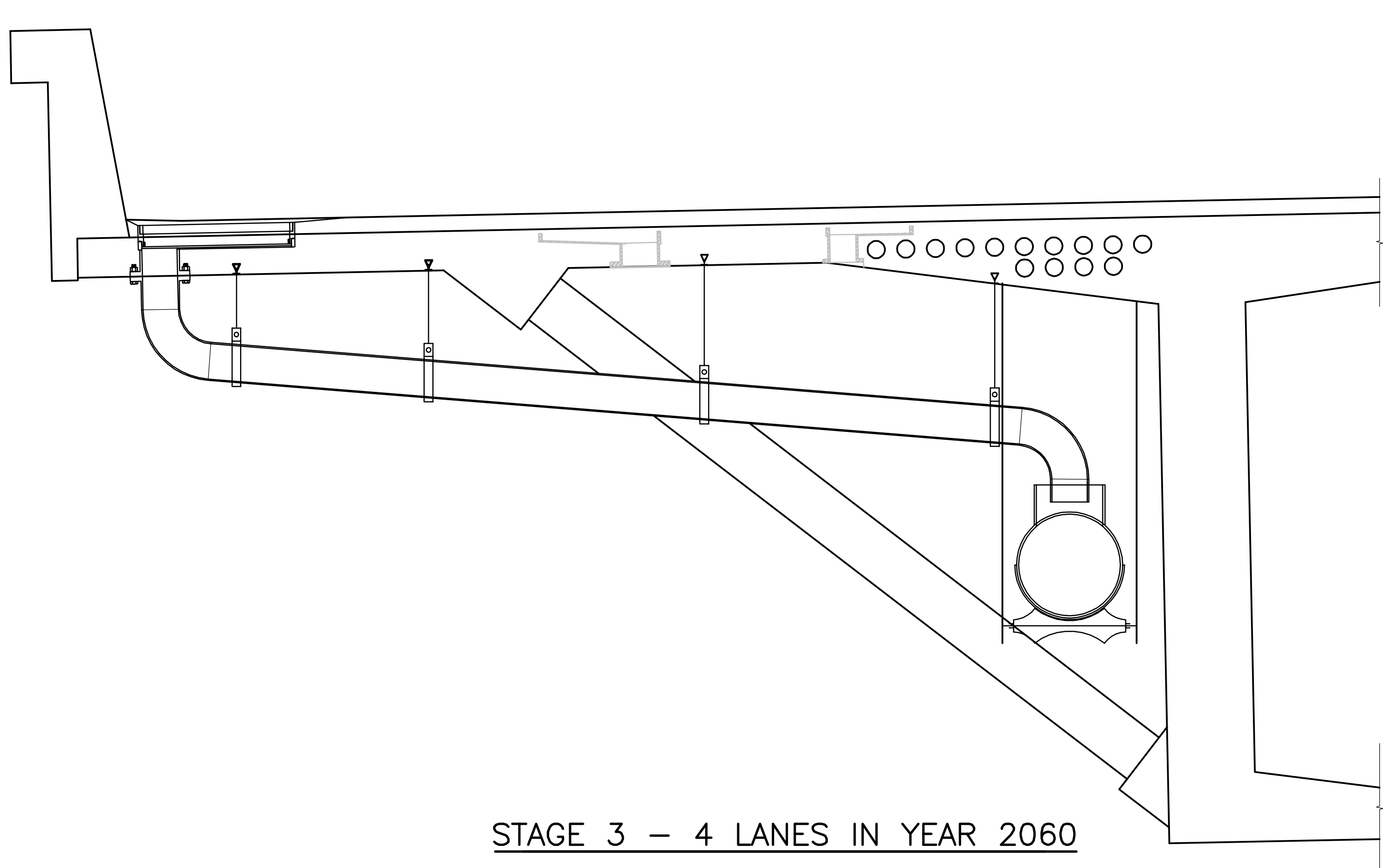


STAGE 1 – 2 LANES IN YEAR 2003



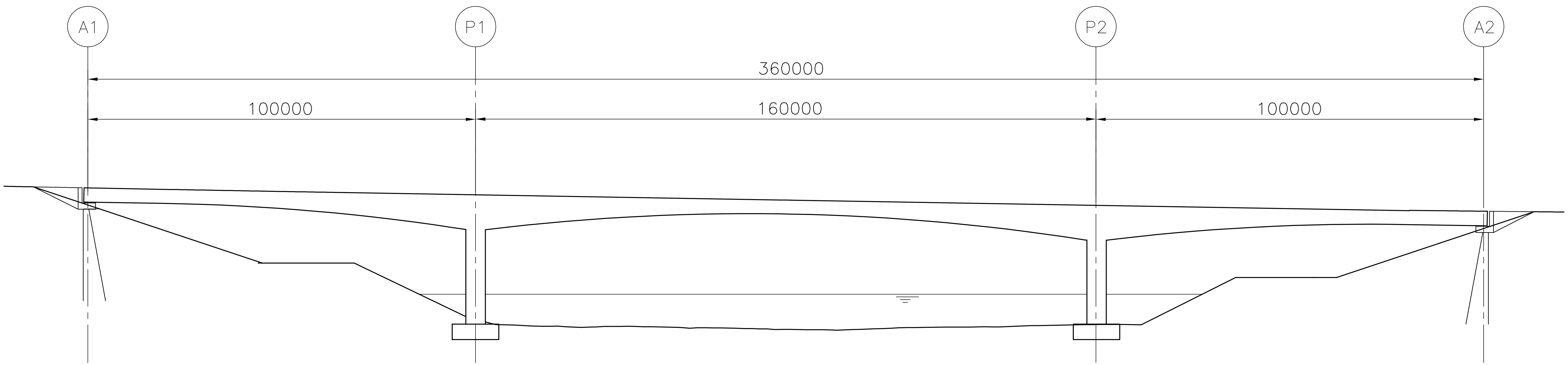
STAGE 2 – 3 LANES IN YEAR 2020



STAGE 3 – 4 LANES IN YEAR 2060

DECK DRAINAGE DETAILS

1:20



BRIDGE ELEVATION

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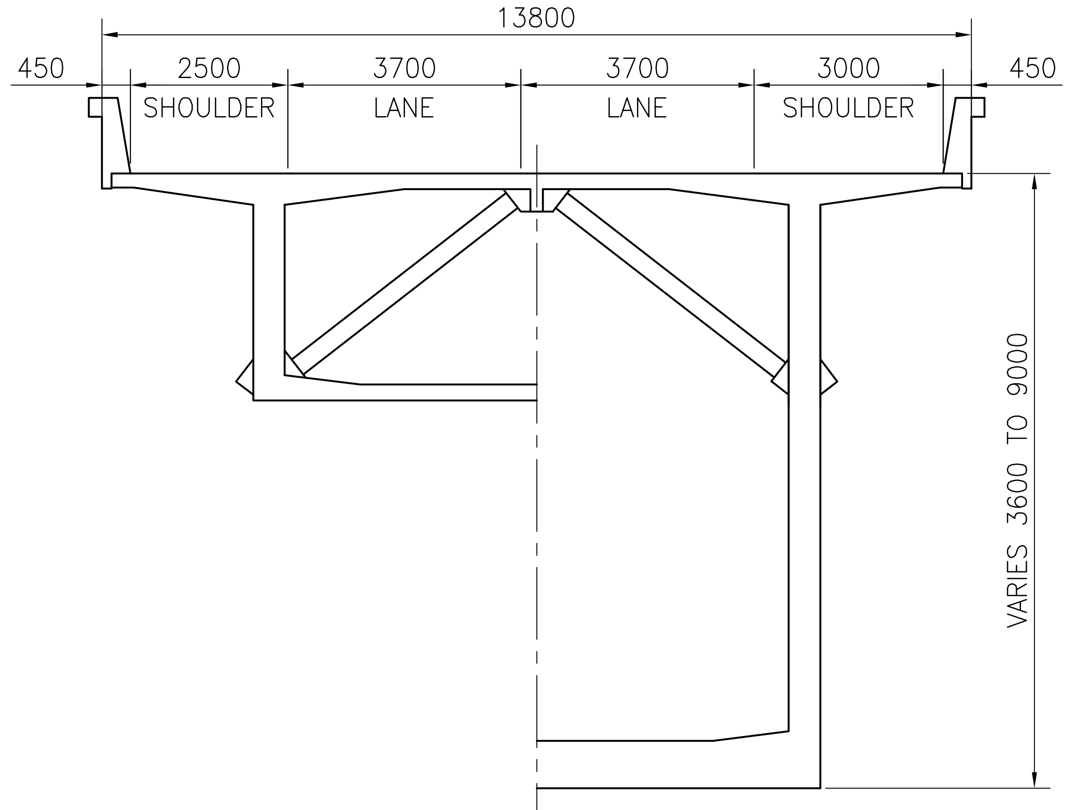
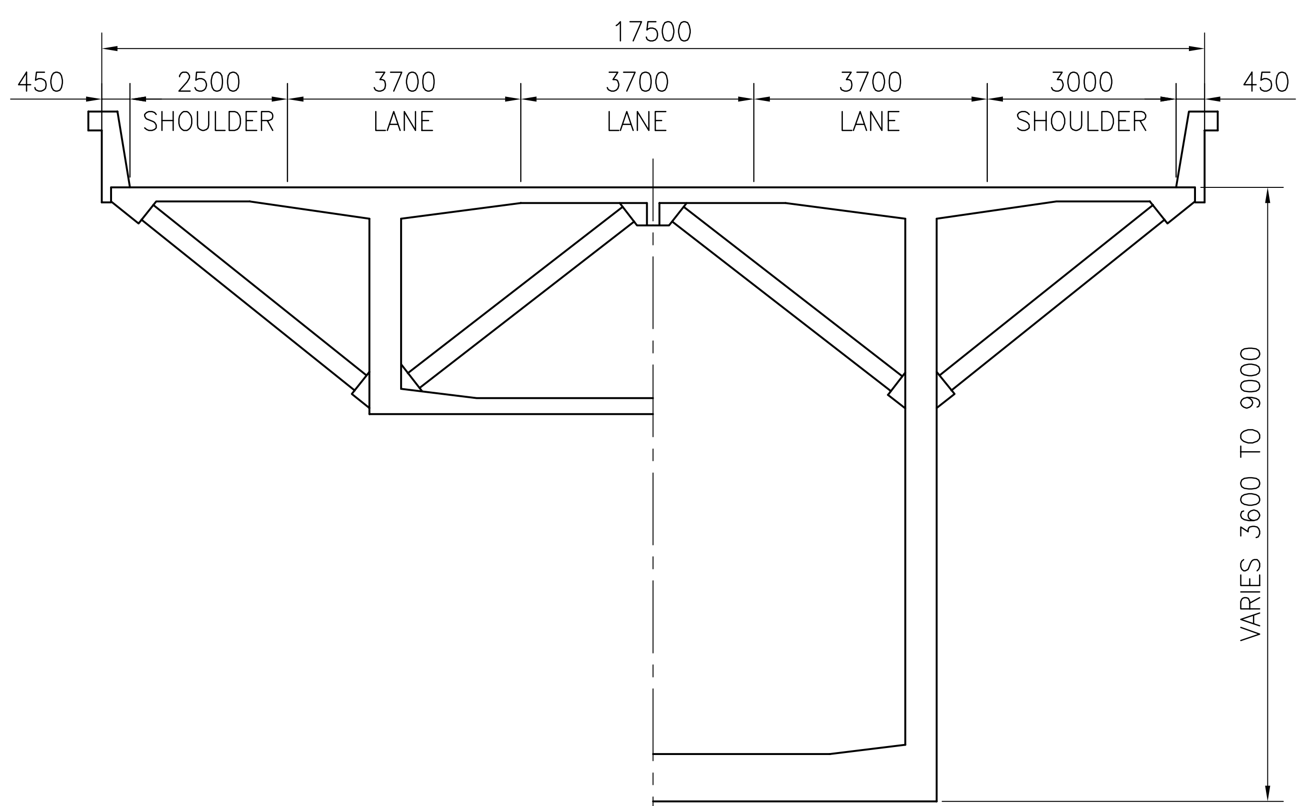


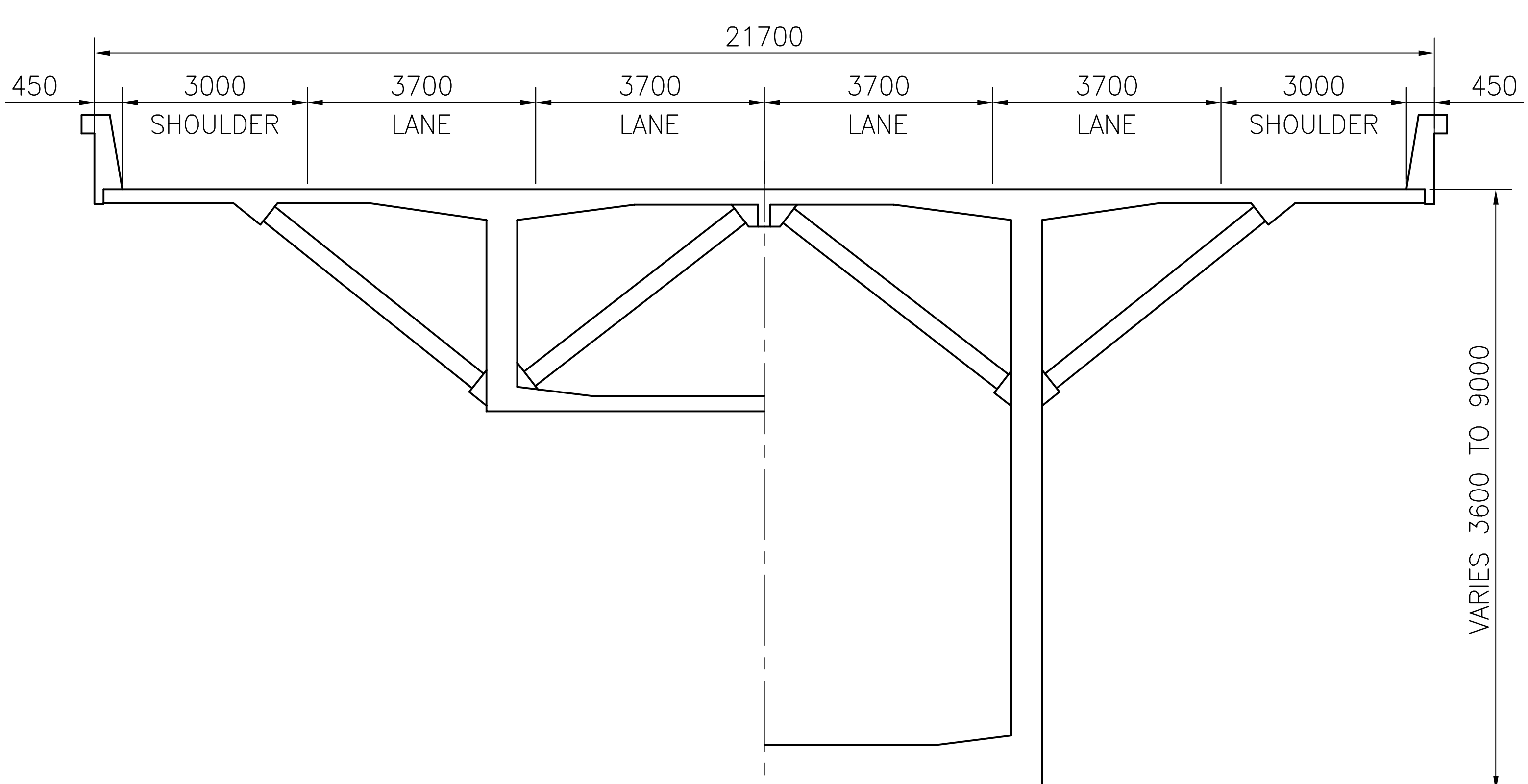
SECTION AT MIDSPAN SECTION AT PIER

STAGE 1 – 2 LANES IN YEAR 2003



SECTION AT MIDSPAN SECTION AT PIER

STAGE 2 – 3 LANES IN YEAR 2020

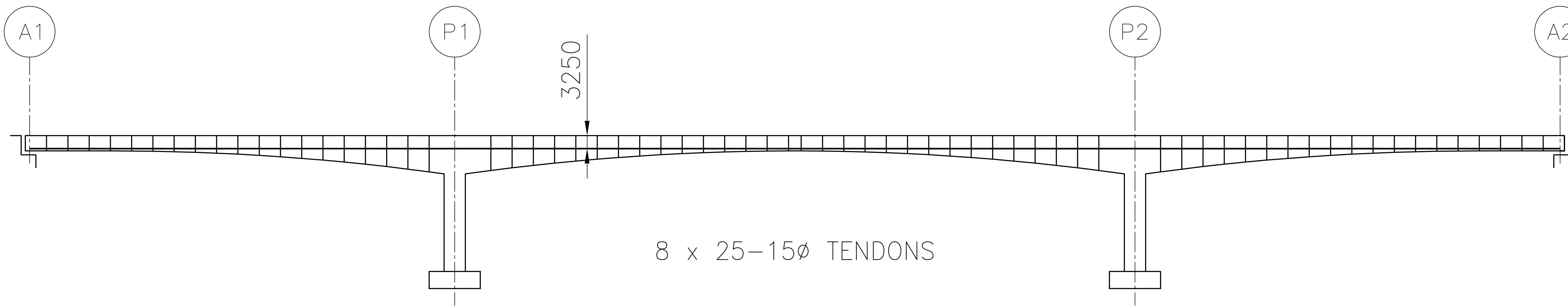


SECTION AT MIDSPAN SECTION AT PIER

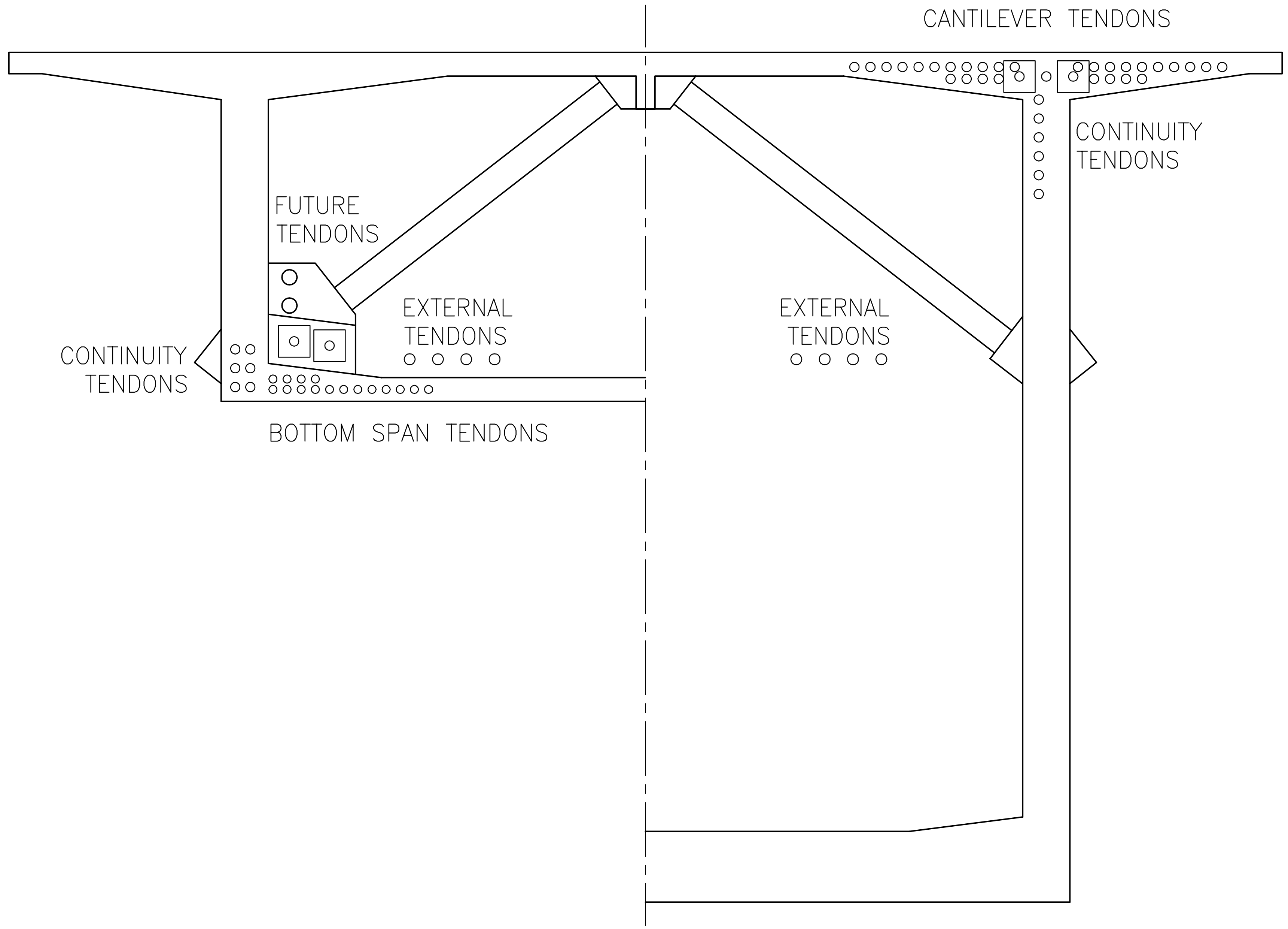
STAGE 3 – 4 LANES IN YEAR 2060

CROSS SECTION WIDENING

1:120



EXTERNAL TENDON LAYOUT
1:1000

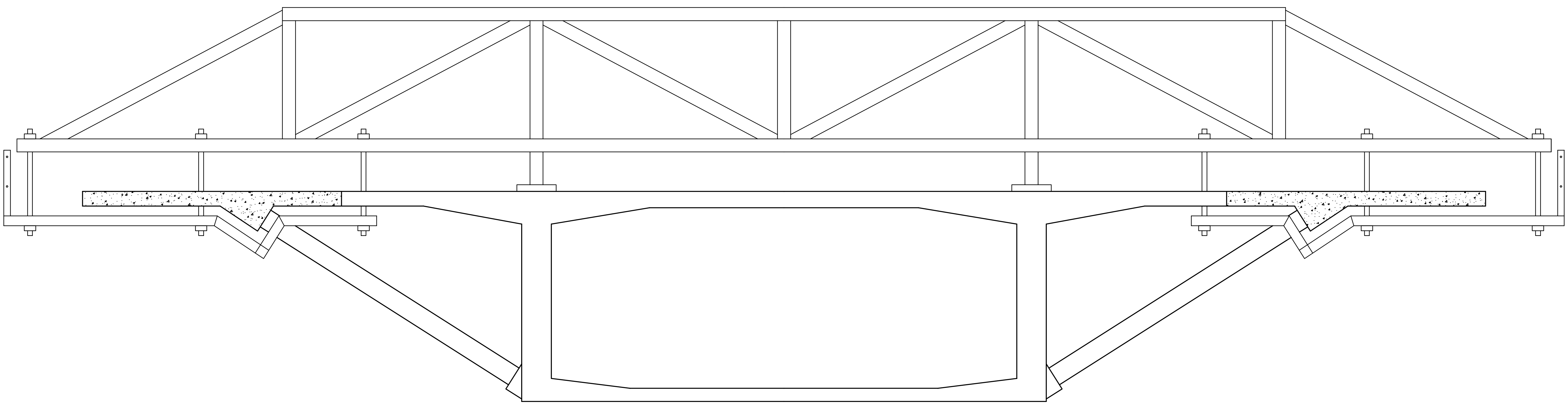


SECTION AT MIDSPAN

SECTION AT PIER

BULKHEAD DETAILS

1:60

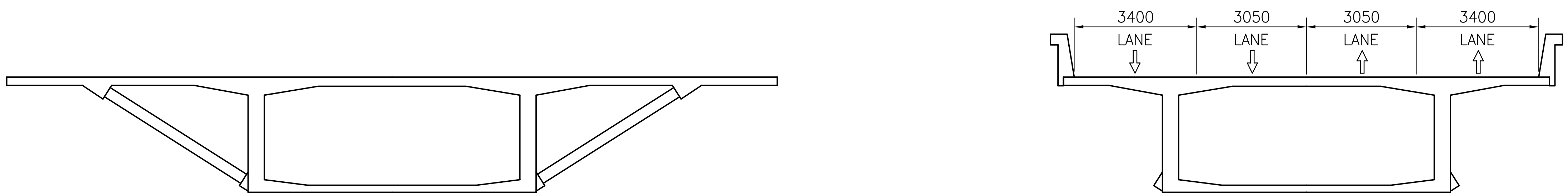


CONSTRUCTION METHOD

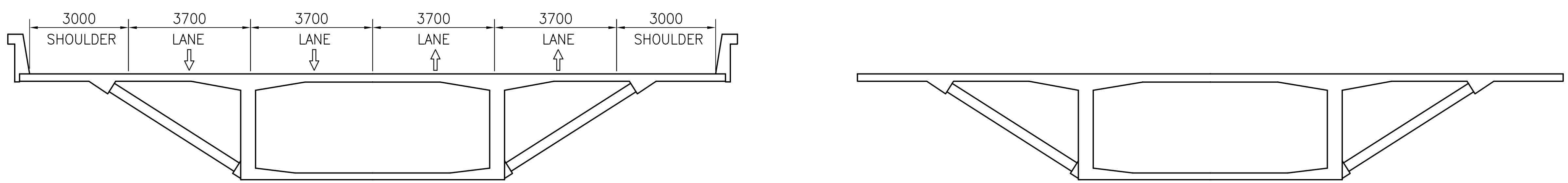
1:60

1 TWO LANES PLUS SHOULDERS EACH WAY

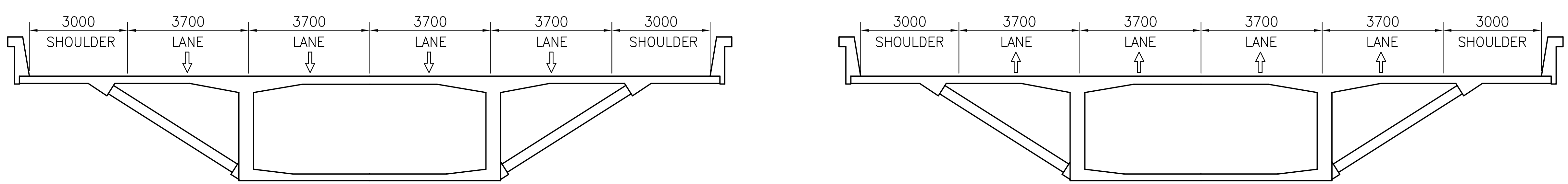
2 TRANSFER TRAFFIC TO EASTBOUND BRIDGE AND WIDEN WESTBOUND BRIDGE



3 TRANSFER TRAFFIC TO WESTBOUND BRIDGE AND WIDEN EASTBOUND BRIDGE



4 FOUR LANES PLUS SHOULDERS EACH WAY



CONSTRUCTION STAGING

1:150