PUNJAB RESILIENT AND INCLUSIVE AGRICULTURE TRANSFORMATION (PRIAT) PROJECT

(WORLD BANK FINANCED)

Precast Concrete Parabolic Segments (PCPS) for Watercourse lining

ADDITIONAL INFORMATION
PRE-QUALIFICATION DOCUMENT (PQD)

DIRECTORATE GENERAL AGRICULTURE (WATER MANAGEMENT) PUNJAB LAHORE

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1. PROJECT BRIEF

The World Bank assisted "Punjab Resilient and Inclusive Agriculture Transformation (PRIAT)" project was approved by the Executive Committee of the National Economic Council (ECNEC) on 07.10.2022 at a total cost of Rs. 68,672.560 million for its implementation during five years (2022-23 to 2026-27) in the entire Punjab. The World Bank IDA financing is US$ 200 million/ SDR 148.8 million, whereas the Punjab Government counterpart share is Rs. 9,072.000 million, and the farmers' contribution is Rs. 13,737.00 million.

2. OBJECTIVES

The Project Development Objective (PDO) of the project is "to enhance equitable access to, and productivity of, agricultural water, and improve incomes of farmers supported by the project".

i) Upgrade on-farm community irrigation conveyance network in canal and non-canal command areas to improve equitable access of water between head & tail-end farmers and improve water conveyance efficiency.

ii) Transform climate smart agriculture production systems through reformatory water management practices, renewable energy, regenerative agriculture, and high value agriculture technologies.

iii) Improve agriculture value chain through crop diversification, harvesting & value addition, and market integration.

iv) Strengthen private sector service delivery capacity for promotion of climate resilient high value profitable agriculture.

v) Develop capacity of stakeholders to adopt climate smart and high value agricultural practices for enhancing profitability and building resilience.

vi) Generate employment opportunities and green jobs to improve living standards and alleviate poverty in rural areas of the province

3. KEY COMPONENTS

i) **Improvement of 1,000 unimproved watercourses**

ii) **Extension of lining on 2,000 partially improved watercourses.**

iii) **Reconstruction and extension of lining on 1,000 outlived watercourses**

iv) **Development of 3,000 irrigation schemes outside canal commands areas**

v) Improving community water management (pilot test of water accounting & budgeting)

vi) Promotion of regenerative agriculture, crop diversification, harvesting, processing, agriculture value addition, and inclusive access to markets

vii) Installation of high efficiency irrigation systems (HEIS) on 40,000 acres

viii) Installation of solar system for operating HEIS on 20,000 acres

ix) Provision of certified orchard plants and vegetable seeds/ seedlings on 5,000 acres

x) Development of 1,000 on-farm water storage/ rainwater harvesting ponds

4. PROJECT LOCATION

Entire Punjab

5. GESTATION PERIOD

Five years (2022-23 to 2026-27)

6. IMPLEMENTATION MODALITIES

The major activities related to the rehabilitation/ development/ improvement of water conveyance system to be carried out under the PRIAT include the followings.

- **Upgrading Farm Level Irrigation Conveyance System through**
    - **Improvement of 1,000 unimproved watercourses**
    - **Extension of lining on 2,000 partially improved watercourses.**
    - **Reconstruction and extension of lining on 1,000 outlived watercourses**
    - **Development of 3,000 irrigation schemes outside canal commands areas**

6.1 Watercourse Improvement

A community watercourse is a complex miniature irrigation channel that receives water from a distributary or minor through a canal outlet "Mogha" and delivers it to farmer fields in the entire command of watercourse in accordance with the weekly water rotation (warabandi) schedule. It is also called "Sarkari or Main Khal" (government watercourse) with a length varying from 3-5 km, discharge of 25-75 lps, command area of 300-500 acres (121-202 ha), and shareholders of about 30-50. Water flows continuously in a watercourse provided that water is available in the minor or distributary. During water conveyance, a significant portion of irrigation water (about 40-50%) is lost in old community watercourses because of seepage, spillage, side leakage, aging, irregular profile, zigzag alignment of banks, frequent bank cutting, poor maintenance, etc. requiring its rehabilitation/ improvement/ lining. Watercourse improvement, therefore, comprise the following activities.

i) **Earthen improvement** involving complete demolishing of community channel and rebuilding according to engineering design with clean compacted soil.

ii) **Lining**- the most important part of watercourse improvement carried out in reaches prone to maximum water losses.

iii) **Installation of necessary water control structures** i.e. naccas, culverts, buffalo wallows, drop structures, siphon/aqueducts, etc.

6.2 Lining Technology

The standard lining executed under previous OFWM projects has been a rectangular shaped channel constructed using double brick masonry walls and a brick masonry floor plastered inside and on top of the walls. This type of lining, being easy to install, has been used since the inception of the OFWM program in 1976. Due to lack of awareness about **Precast Concrete Parabolic Segment (PCPS)** and farmers' preference for more familiar and easily available use of brick masonry, most watercourses improved earlier in Punjab used bricks. However, there was the dire need to adopt lining alternatives to overcome the multifarious problems faced in the field under continuous rise in demand for bricks, little price control, and deteriorating quality of bricks. The PCPS lining was, accordingly, tested and adopted, being hydraulically more efficient, durable, quick in installation, and relatively more economical. The OFWM engaged extensively with WUA and private sector suppliers of PCPS to demonstrate its benefits and economic advantages. The findings of an assessment conducted by project M&E consultants showed that PCPS lining costs 3% less per meter compared to the brick lining, takes less time to construct, and is easier to maintain. **Accordingly, the PCPS technology will be adopted under the PRIAT for watercourse improvement of all types in Punjab**.

Figure 1. Precast Concrete Parabolic Segments (PCPS)

6.3 Implementation Procedure

- The department has planned to pre-qualify Precast Concrete Parabolic Segments (PCPS) supplier firms/ SSCs to supply material for watercourse lining/ improvement.
- The PRIAT will adopt a Community Driven Development (CDD) mechanism for lining/ improvement of community watercourses.
- Water Users Associations (WUAs) consisting of shareholders of watercourse would be organized at each watercourse.
- WUA will procure the construction materials from the prequalified PCPS firm/ SSCs, etc. living within the upper ceiling rates fixed by the District Rate Committee (DRC) for the tehsil/ cluster and carry out civil works under the technical supervision of OFWM field staff and supervisory consultants.
- The concerned OFWM staff will conduct internal monitoring of construction works while supervisory and monitoring consultants will undertake external monitoring to ensure the quality of works.
- The funds for watercourse improvement/ lining activity will be transferred from Provincial Account-I to Cost Centers/ DDO Codes of respective Deputy Director Agriculture (OFWM) at district level.
- The Deputy Director Agriculture (OFWM) will release the funds into the joint account of respective WUA on recommendations of supervisory consultants as per approved criteria.
- Further, payments made from the joint account of WUA to PCPS suppliers/SSCs/ firms will be made by WUA in accordance with the millstones of civil work completed. The schematic process for improvement of watercourses is shown in Figure 2 & 3.

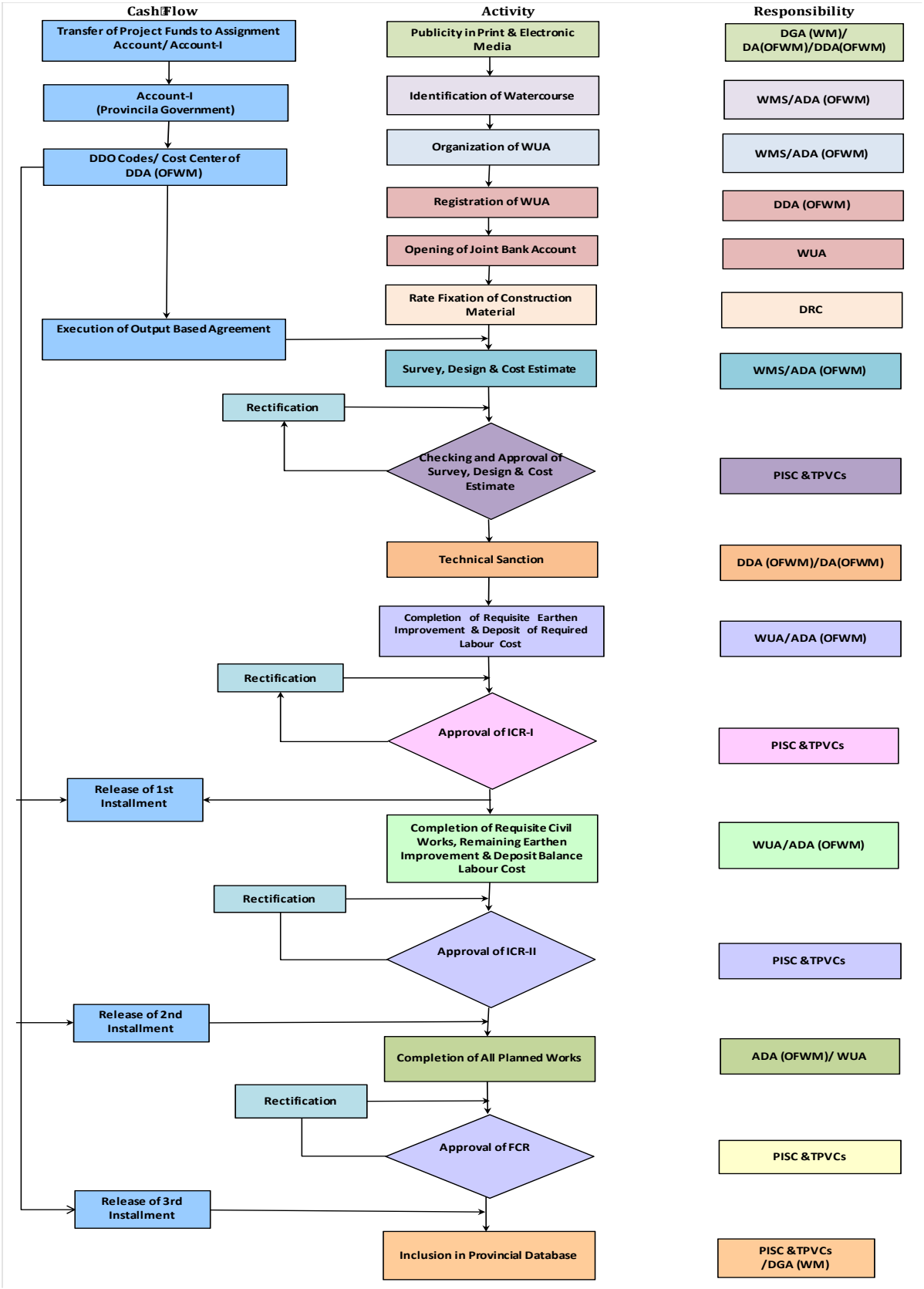


Figure 2. Schematic process for watercourse improvement

Figure 3. Watercourse improvement process

6.4 Available Standard PCP Segments

Depending upon varying design capacities and available longitudinal slopes, a series of PCP segments (Segment No. 1 to 8) have been designed that can be manufactured and used for watercourse lining. Sanctioned discharges in various canal commands and available longitudinal slopes in different areas of the Punjab province generally allow use of Segment No. 3 to 8 for lining of watercourses in canal irrigated areas whereas, Segment No. 1, 2 & 3 are feasible for tubewell watercourses in non-canal commands of the province. It is indicated that Segment No. 8 is rarely needed for exceptionally high flows. A summary of presently available different segment sizes alongwith their hydraulic dimensions is given in **Table 1** while the construction materials required for each size of segments are given in **Table 2**.

Table 1: Segment Sizes and their Hydraulic Dimensions

Segment Size			Top Width	Depth	X-Sectional Area	Perimeter	Equation Coefficient
No.	Section (mm x mm)	Length (mm)	T (mm)	D (mm)	A (sq.m)	P (mm)	(a)
1	360 x 225	1220	360	225	0.054	593	0.006944
2	457 x 305	920	457	305	0.093	783	0.005842
3	600 x 360	920	600	360	0.144	966	0.004000
4	640 x 460	920	640	460	0.196	1150	0.004492
5	675 x 480	920	675	480	0.216	1204	0.004214
6	760 x 530	920	760	530	0.269	1339	0.003670
6a	800 x 600	920	800	600	0.320	1507	0.003750
7	920 x 610	920	920	610	0.374	1571	0.002883
7a	960 x 686	920	960	686	0.439	1751	0.002977
8	1144x 686	920	1144	686	0.523	1841	0.002097

Table 2: Construction Materials Required for Various PCPS Sizes

Segment Size			Concrete Weight	Aggregate Volume	Quantities of Construction Material with Mix Ratio of 1 : 1 : 2		
			per seg	per seg.	Cement	Sand	Gravel
No.	Section (mm x mm)	Length (mm)	(kg.)	(cu.m)	(bags)	(cu.m)	(cu.m)
1	360 x 225	1220	86.36	0.0558	0.414	0.015	0.029
2	457 x 305	920	102.72	0.0661	0.490	0.017	0.035
3	600 x 360	920	122.90	0.0790	0.586	0.021	0.041
4	640 x 460	920	162.26	0.1044	0.774	0.027	0.055
5	675 x 480	920	173.02	0.1112	0.825	0.029	0.058
6	760 x 530	920	228.37	0.1466	1.087	0.038	0.077
6a	800 x 600	920	261.40	0.1677	1.244	0.044	0.088
7	920 x 610	920	286.01	0.1835	1.361	0.048	0.097
7a	960 x 686	920	308.09	0.1977	1.466	0.052	0.104
8	1144x 686	920	308.42	0.1980	1.469	0.052	0.104

Note: Materials include permissible wastage

6.5 Concrete Specifications

i) Suggested mix ratio of 1:1:2

ii) 28 days curing with cylinder compressive strength of 4500 psi

iii) 70 percent of specified strength after 07 days and 85 to 90 percent after 14 days curing

iv) Maximum 01inch slump

v) Precast only under approved conditions, with compaction by vibrating table, to be casted in only consultant's approved steel molds

vi) Recommended water cement ratio of 0.36

vii) Minimum 7 days curing (water) or fully covered by steam.

viii) Aggregate sizes vary from minimum 3/8" to maximum of 3/4". Manufacturer will adjust proportions of aggregate size to achieve the specified strength. For Segment No. 1, 2 and 3, maximum recommended aggregate size is 1/2".

ix) The sand shall be obtained from an approved source. It shall be well graded. The whole sand should be passed through consultant's recommended sieves as per standards.

x) Sand and gravel may be washed before use

xi) SR cement is recommended for PCP segments to be installed in saline areas particularly in southern Punjab

xii) Mortar of 1:3 cement sand ratio shall be applied in the joints

6.6 Installation/ Jointing of PCPSs

To facilitate the installation of PCP lining, about 07 cm thick layer of compacted sand is laid over an already prepared firm bed (of desired compaction). The PCP segments are then placed on this sand bed by following proper alignment and ensuring designed longitudinal slope. Segments are also checked by mason's hand level for their horizontal position to ensure proper jointing of male and female ends of each segment. The joints are then properly filled with mortar and cured for a minimum period of seven days. The required quantities of sand for the bed and that of cement & sand for mortar to be placed in jointing for each segment size are given in **Table 3**.

Table 3. Materials Required for Jointing and Sand Bed Preparation

Segment Size			Material Required Per Joint With Cement Sand Ratio of 1:3		Sand Required Per Segment for Bed Preparation
			Cement	Sand	
No.	Section	Length	(bags)	(cu.m)	(cu.m)
1	360 x 225	1220	0.0022	0.00024	0.053
2	457 x 305	920	0.0037	0.00039	0.044
3	600 x 360	920	0.00445	0.00047	0.044
4	640 x 460	920	0.0062	0.00065	0.047
5	675 x 480	920	0.0065	0.00069	0.044
6	760 x 530	920	0.0089	0.00094	0.046
7	920 x 610	920	0.0115	0.00121	0.049
8	1144x 686	920	0.0121	0.00128	0.051

Note: Materials for jointing include permissible wastage

6.7 Procurements of PCPS

Following guidelines shall be observed during the procurement process of PCP segments:

- Firms shall be pre-qualified at provincial level.
- Supply of PCPS would be acceptable from the prequalified firms only.
- All firms will ensure embossing the date, Lot No. and trade mark/name of firm on each segment at the time of fabrication.
- The computer spreadsheets developed by the project consultant shall be provided to all Field Engineers and DDA (OFWM) to facilitate DRCs for assessment of rates of different sized PCP segments on monthly basis or on emergent basis, if required. Prevailing market rates of concrete ingredients (cement, sand & gravel) and transportation charges shall be the only variables to be incorporated in the spreadsheets. Infrastructure and fixed & variable costs shall be assessed on need basis preferably on bi-annual or yearly basis.
- The rates assessed as above shall be the maximum ceilings, based on the prevailing market rates of materials. Rates shall be fixed in Rupees per segment rather than per foot or meter. Purchase committees of watercourses shall be at liberty to purchase PCP segments at cost lower than ceilings without any compromise on quality from any pre-qualified Firm.

6.8 Quality Assurance Mechanisms

A precisely tailored to project-specific environment, an implementable, efficient and reliable arrangements for efficacious testing of PCPSs and outlets (Naccas) would be in place for quality assurance at yards through resident supervision. A very robust and stringent quality assurance mechanism for PCPSs and Naccas will be implemented under the PRIAT; and all

essentially needed tests will performed at production yards to ensure quality of each and every single segment leaving the yard and installed on watercourses. In view of widespread/scattered nature of yards across the Province and a very limited number of authentic/reliable laboratories close to production sites (yards), ever-changing raw material supplies to yards and production on almost daily bases in each yard, it is practically impossible to collect samples of each lot (daily) produced, shift samples to laboratories and wait for their results (passing or failure). Therefore, foolproof arrangements for performing tests commensurate with the standard operating procedures have been incorporated in the project design/criteria for prequalification of firms. Accordingly, it is mandatory for each prequalified yard to ensure availability of requisite equipment within the yard premises equipped with the following mandatory equipment/facilities:

- Compressive Strength Testing Machine
- Schmidt Hammer
- Slump Test Cones
- Sieves Set comprising No. 4,8,16,30,50,1 and 100 sieves for Gradation of Sand
- Sieves Set comprising 1",3/4",3/8",3/16", and 3/32" sieves for Gradation of Gravel
- Digital Weighing Balance
- Oven
- Mason's Level
- Measuring Cylinders

In order to further reinforce the stipulated quality assurance mechanism, Third Party Validation of all PCPSs and Naccas (produced at the Yard(s), by PIS &TPV consultants will be a prerequisite for each PCPS and Nacca produced at Yard(s) and installed on watercourse(s).

To comply with the said obligation, deployment of full-time Sub-Engineers (Diploma holders in Civil Engineering) in the yard(s) of the prequalified firm(s) to ensure pre, during and post Resident Supervision of production of PCPSs and Naccas. The Resident Supervision is further fortified through an effective and vigilant supervision by District & Division Level Field Engineers and the Project Management. The TPV consultants will be equipped to perform a chain of standard tests, right from testing quality of individual constituents i.e., sand, gravel etc. to the finished product. The TPV consultants essentially perform the following Laboratory Tests pertaining to concrete constituents and the end product (PCPSs &Naccas):

- American Standard for Testing Material (ASTM) Gradation and Fineness Modulus Test, Silt Contents & Bulk Density Tests for SAND Quality analyses
- American Standard for Testing Material (ASTM) Gradation & Bulk Density Tests for Gravel Quality Analyses
- Slump Cone Tests for Concrete Consistency Evaluation (Water-Cement ratio)

- Schmidt Hammer (Rebound Hammer) Test for Elastic Properties and Strength of Concrete
- Cubical/Cylindrical Compressive Strength Tests for Establishing Strength of Finished Product (PCPSs and Naccas)

As such, all tests applicable as per international engineering standards for pre-cast concrete structures will be conducted, in an adequately established laboratory in each Yard, by PIS & TPV Consultants/ "the Engineer"; and, PCPSs and Naccas meeting with the Project Standards & Specifications approved/vetted by PIS&TPV will only be installed on watercourses improved under the PRIAT project.

6.9 PCPS Compressive Strength Testing

Concrete can be tested by crushing the cubes/cylinders cast at the time of manufacturing and, by cutting cores of already manufactured/cast concrete and subjecting them to crushing test under laboratory-controlled conditions. However, another method, namely the Schmidt's Hammer testing can be employed for non-destructive testing. Schmidt' hammer test gives a good idea of strength, if homogeneity in concrete exists and the panel under testing is not supported. Schmidt's hammer test, if applied for comparative strength evaluation, is useful tool in testing of concrete. Its reliability can be improved by increasing the number of points tested in one panel/segment. In view of the above, Schmidt's Hammer test with large no. of points would be applied as first-hand information about PCPS strength. However, in case of non-consensus, determination of exact quality of concrete conforming to the contract specifications, core testing would be recommended at the cost of manufacturers.

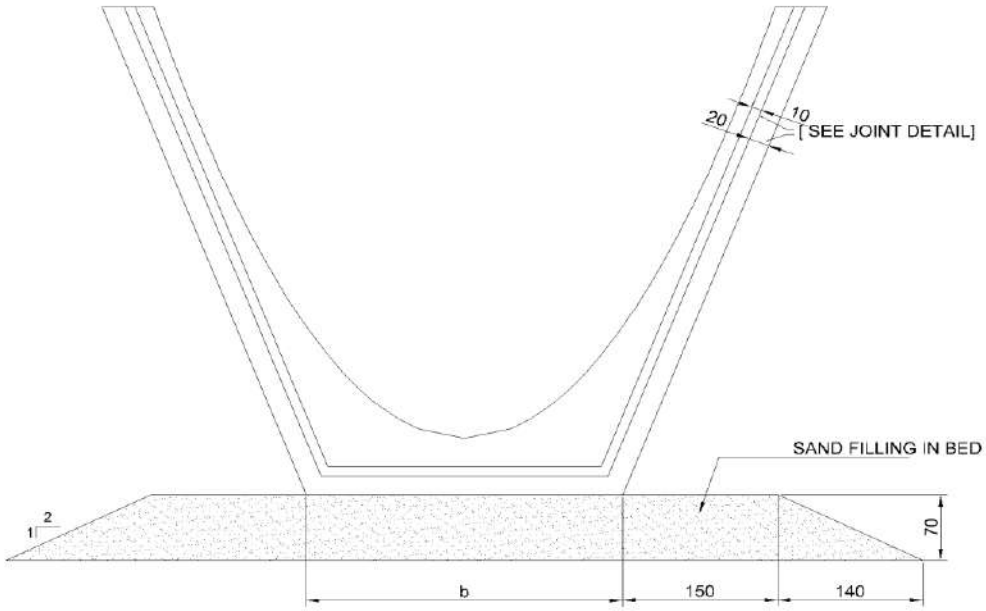
6.10 Quality Control Measures during Fabrication of PCPS at Yards

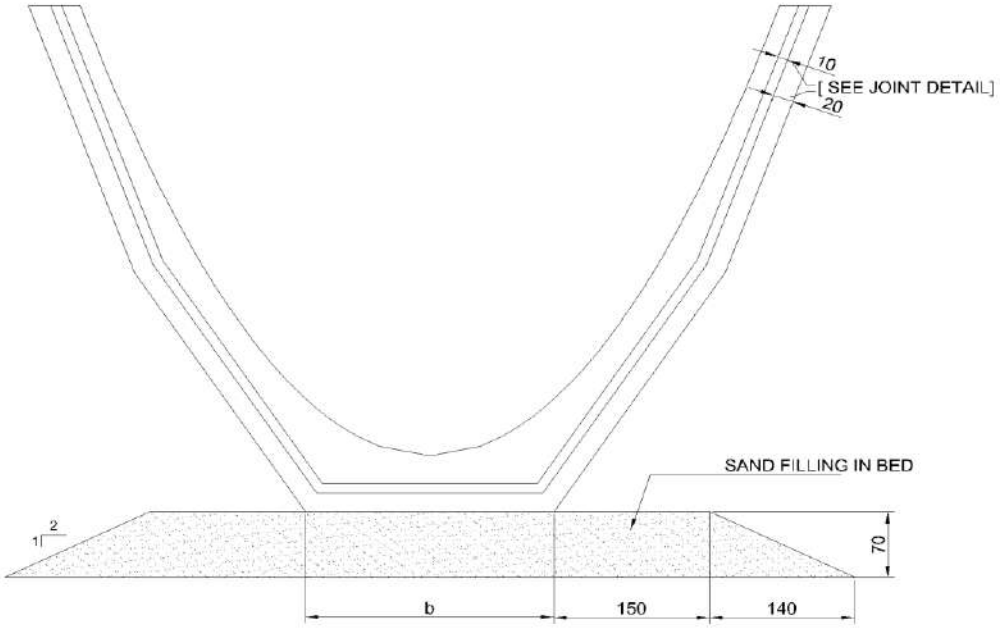
Following important measures along-with strict observance of agreed specifications for PCPS would be ensured at yards:

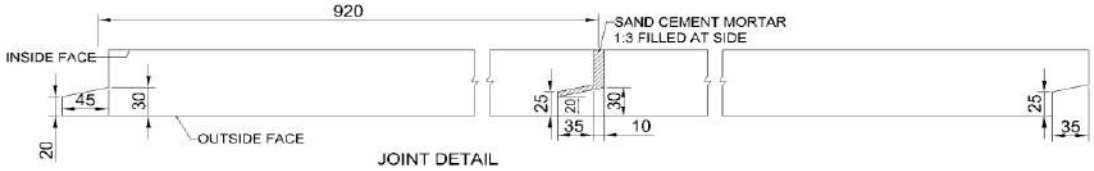
- Resident supervision through supervisory consultants would be ensured for quality control as per department procedure/ policy.
- Achieving inside surface finish of each segment shall be as equally important as its strength. Honey combing/cavities therefore, shall be controlled through proper water cement ratio and vibration time.
- Periodic inspections would be made at yards to ensure regular repair & maintenance of molds to keep each and every mold to produce segments of standard/designed dimensions. Any de-shaped mold shall be discarded immediately.
- Approved drawings **(Annexure-A)** shall be strictly followed during steel molds fabrications to produce segments of true dimensions particularly the geometry

of male and female ends of segments which counts a lot to produce leak proof joints between segments.

- The specifications for PCPS, as already approved by the committee constituted for the purpose, would be followed by the manufacturers at each yard.







JOINT DETAIL

All Dimensions are in mm

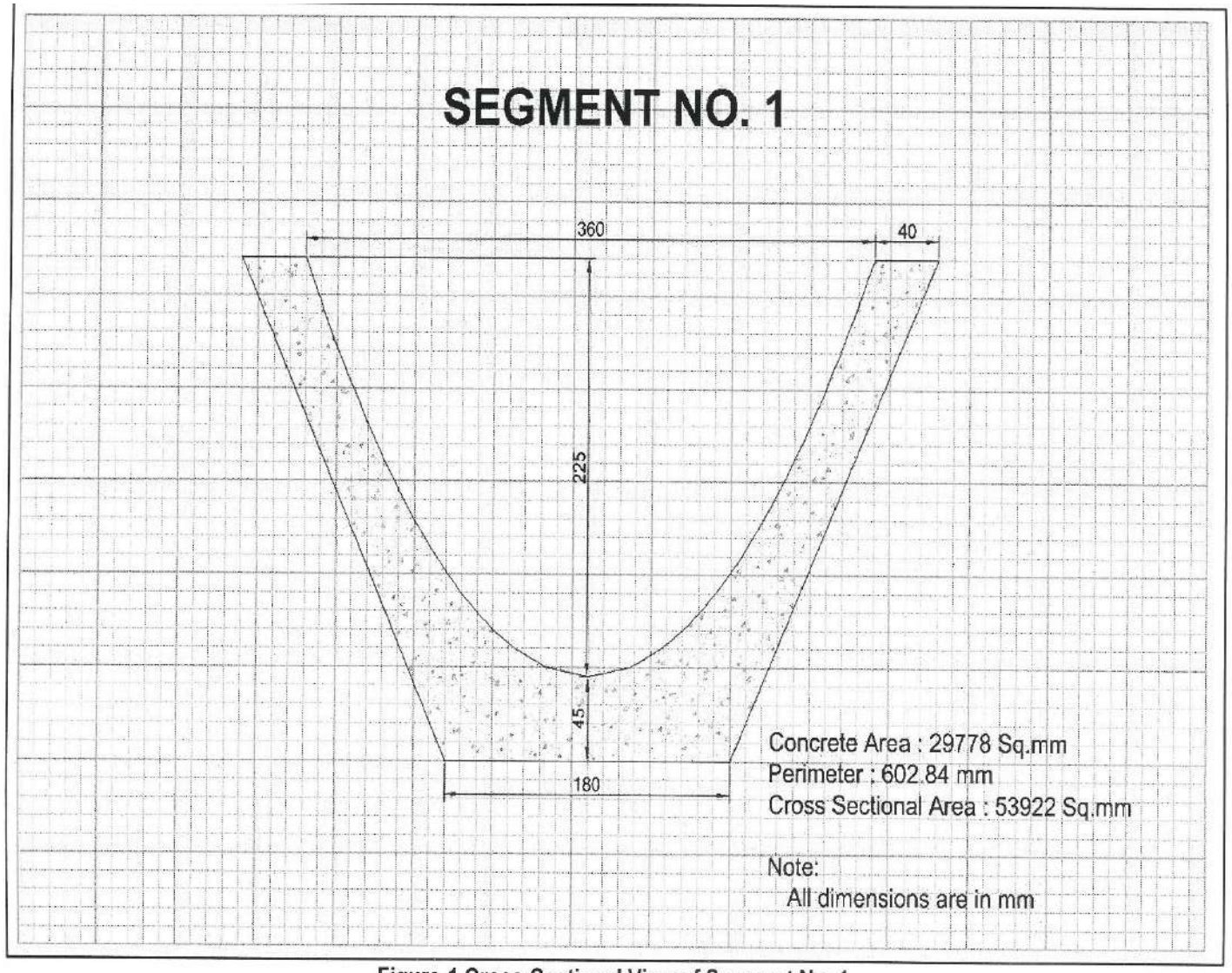


Figure-1 Cross-Sectional View of Segment No. 1

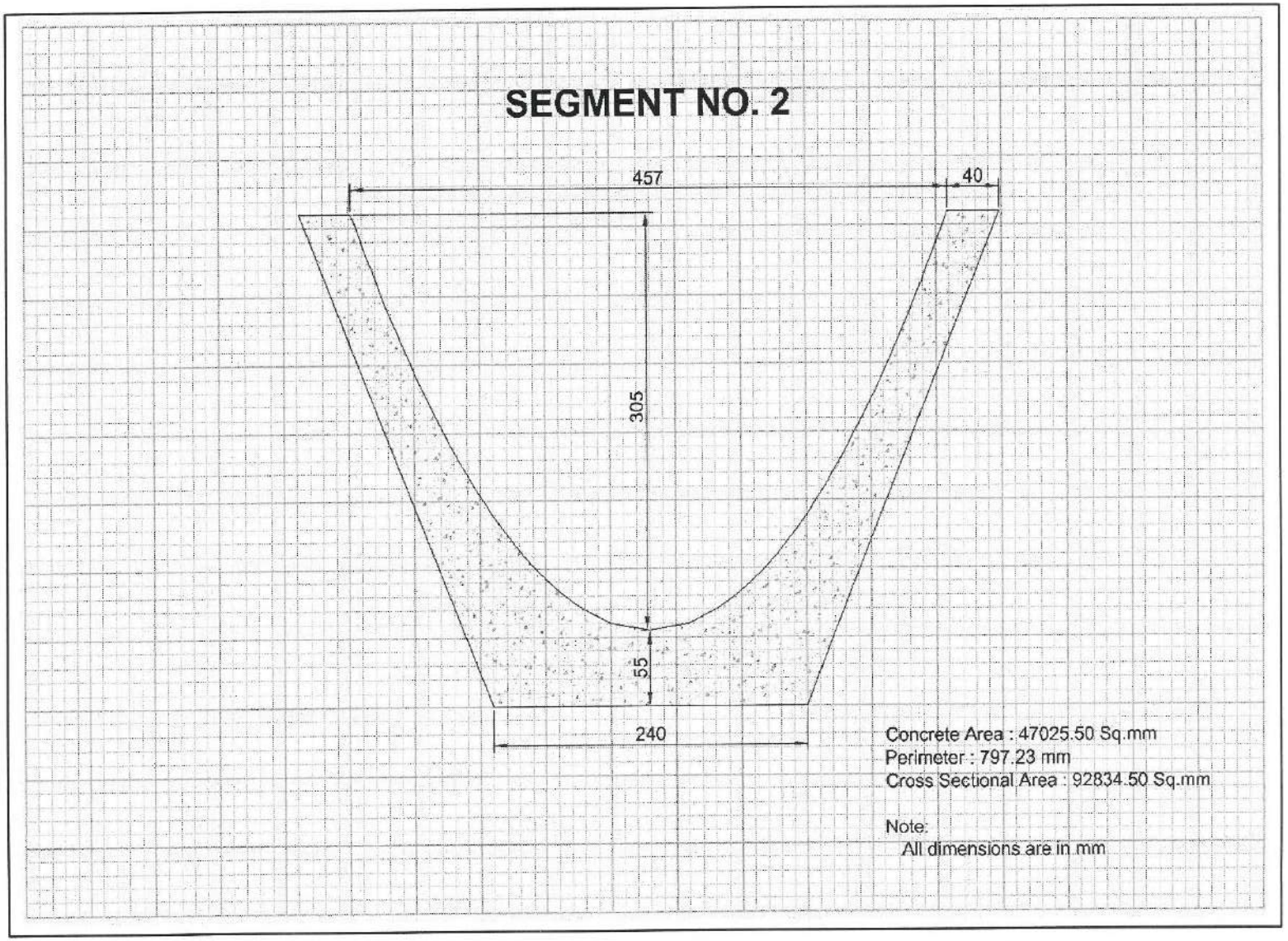


Figure-2Cross-Sectional View of Segment No. 2

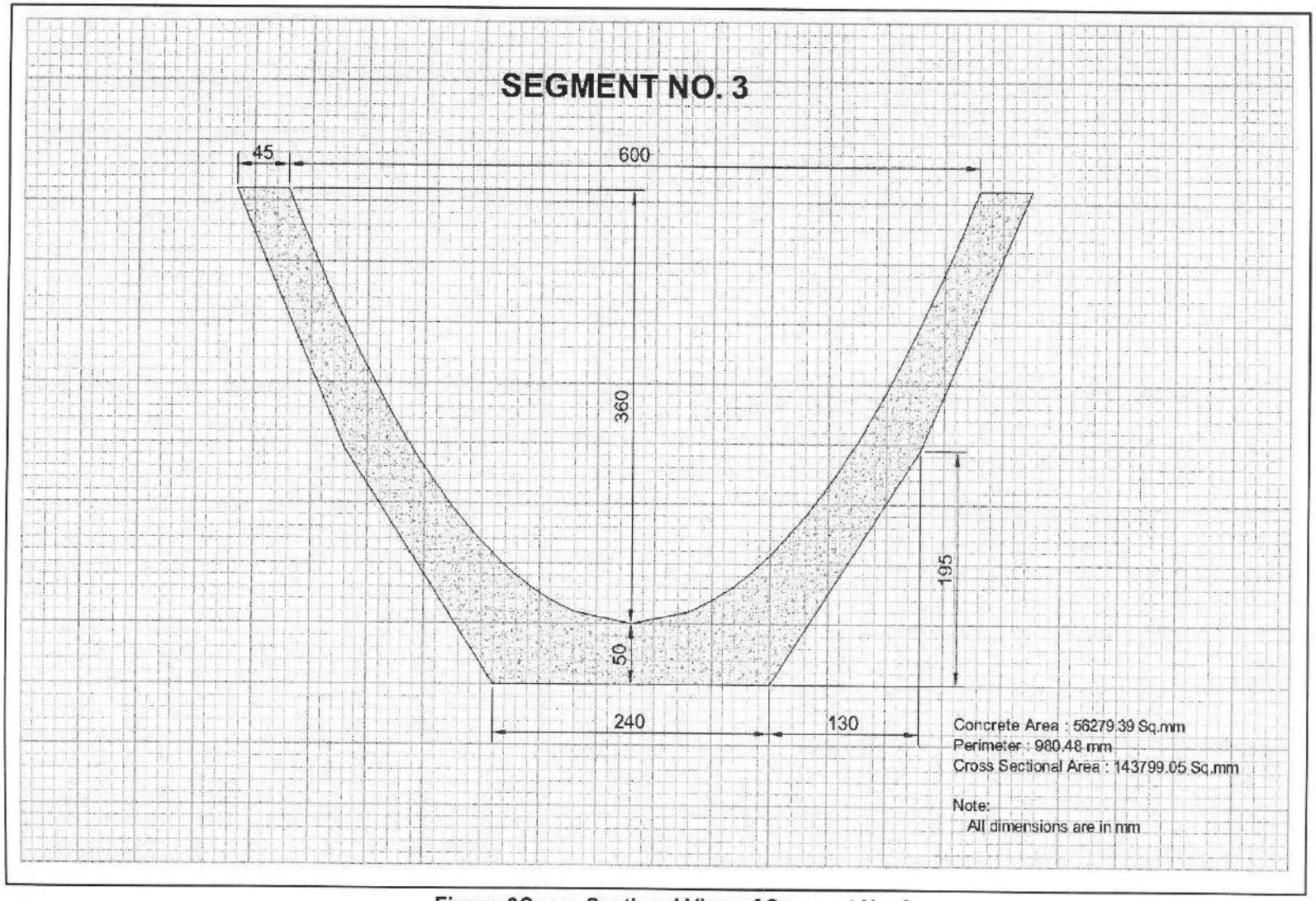


Figure-3Cross-Sectional View of Segment No. 3

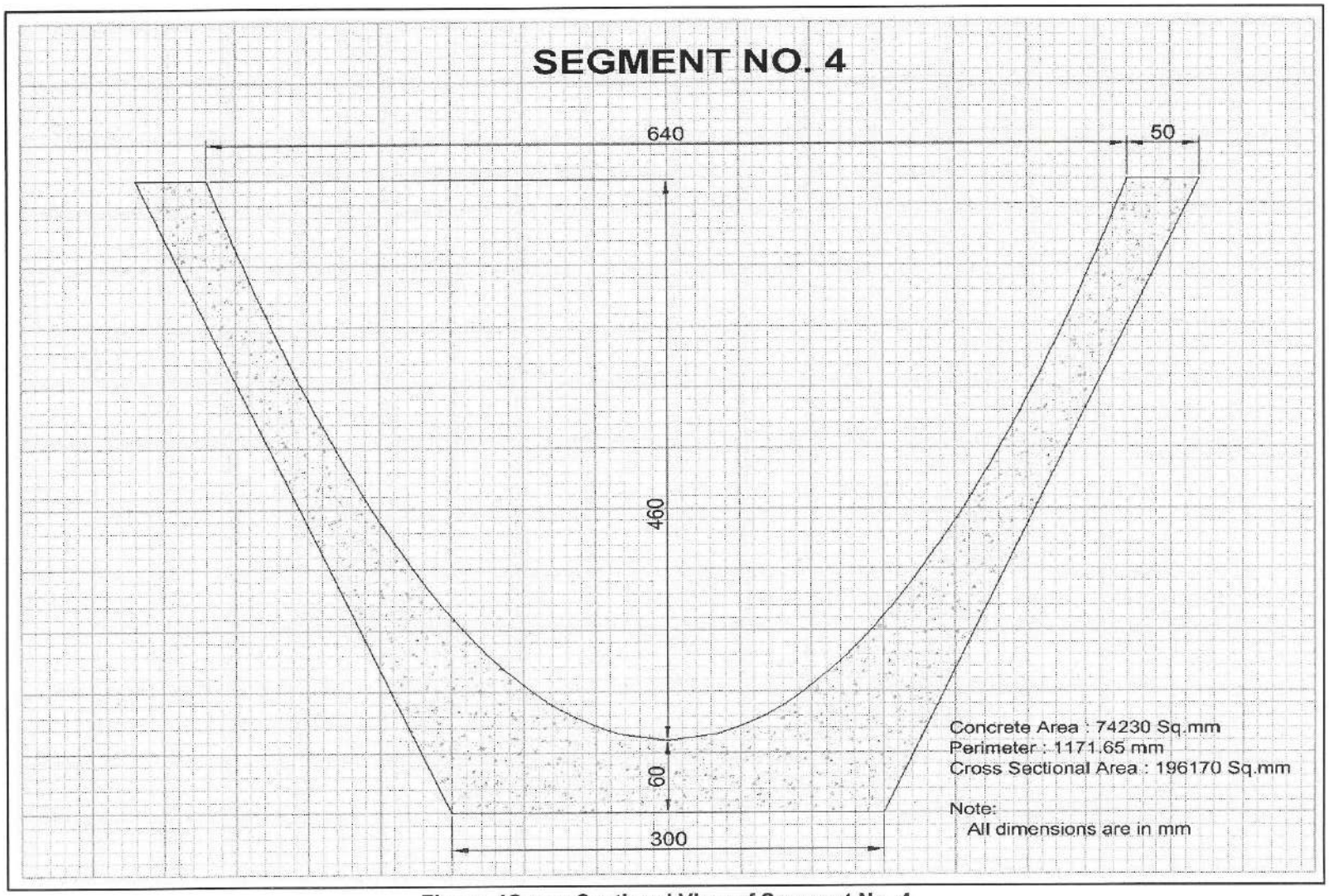


Figure-4Cross-Sectional View of Segment No. 4

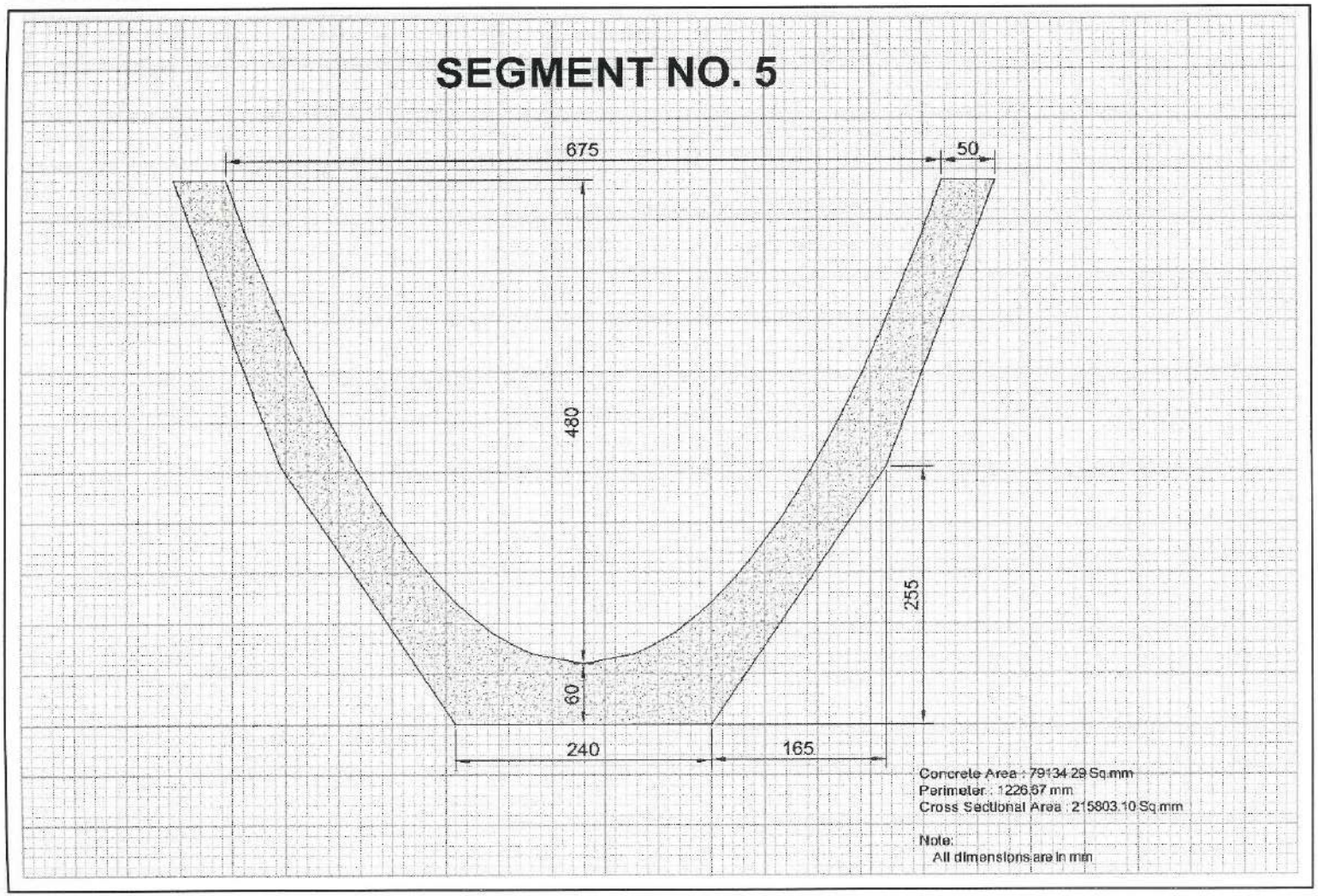


Figure-5Cross-Sectional View of Segment No. 5

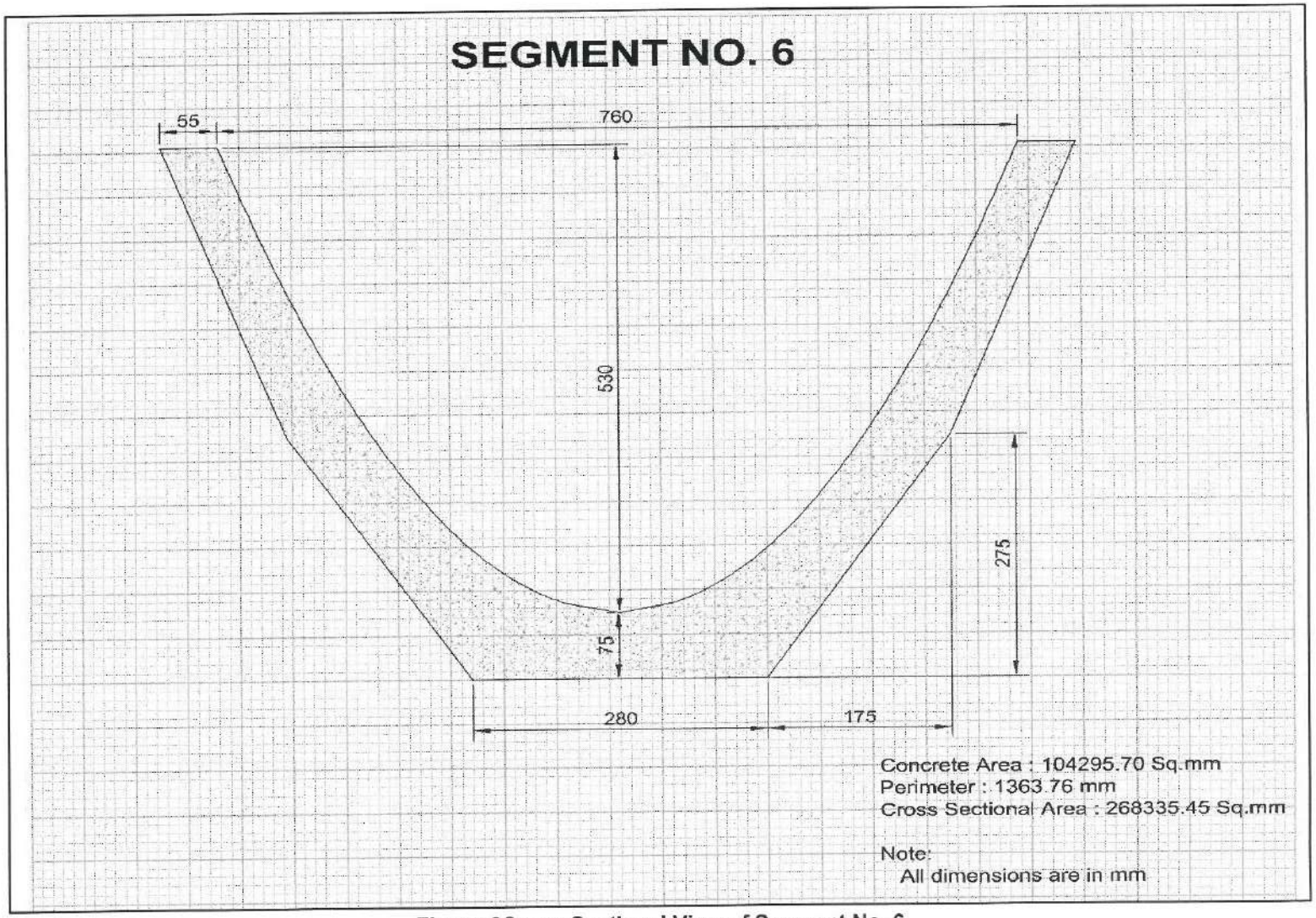


Figure-6Cross-Sectional View of Segment No. 6

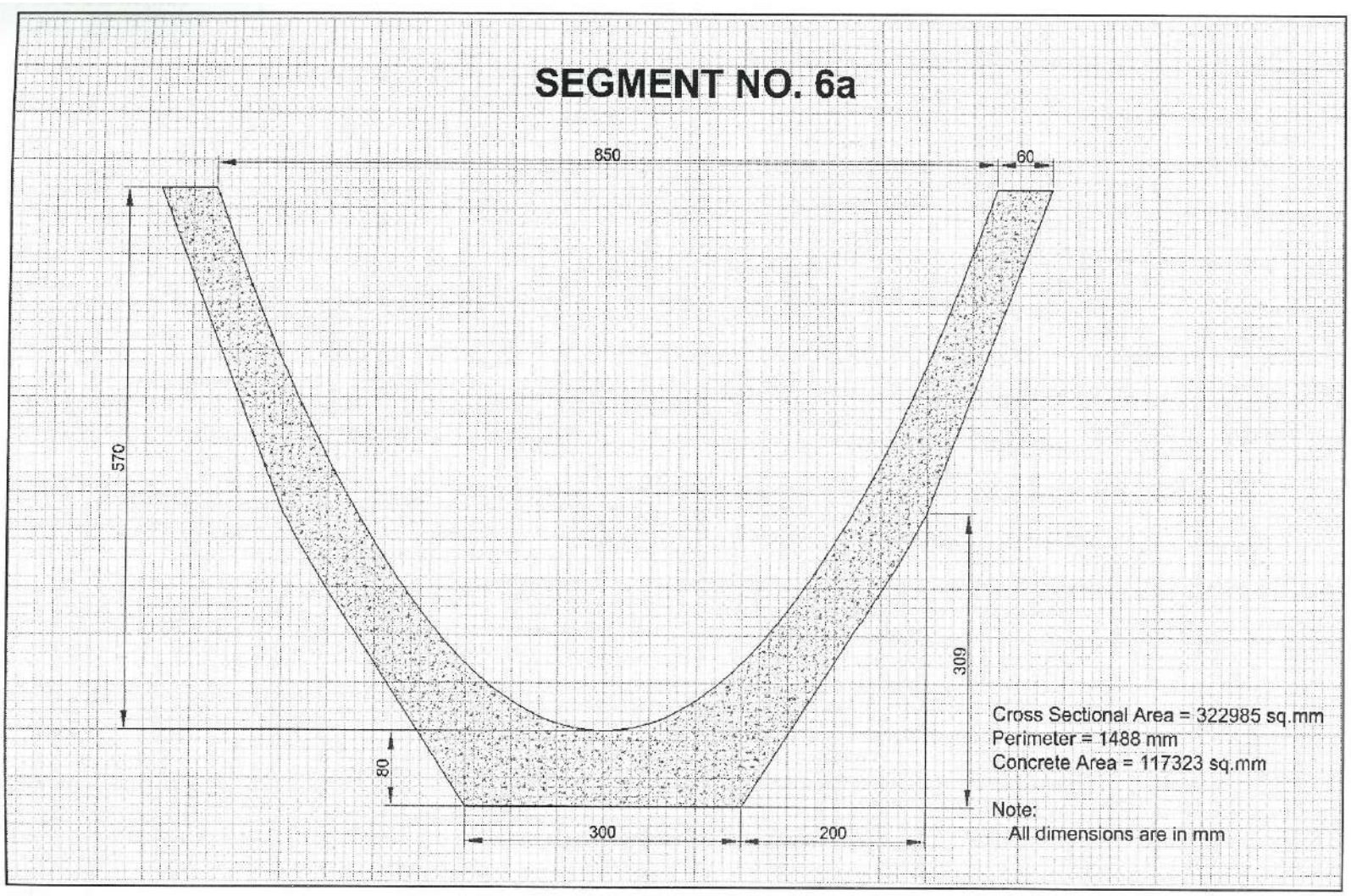


Figure-7Cross-Sectional View of Segment No. 6a

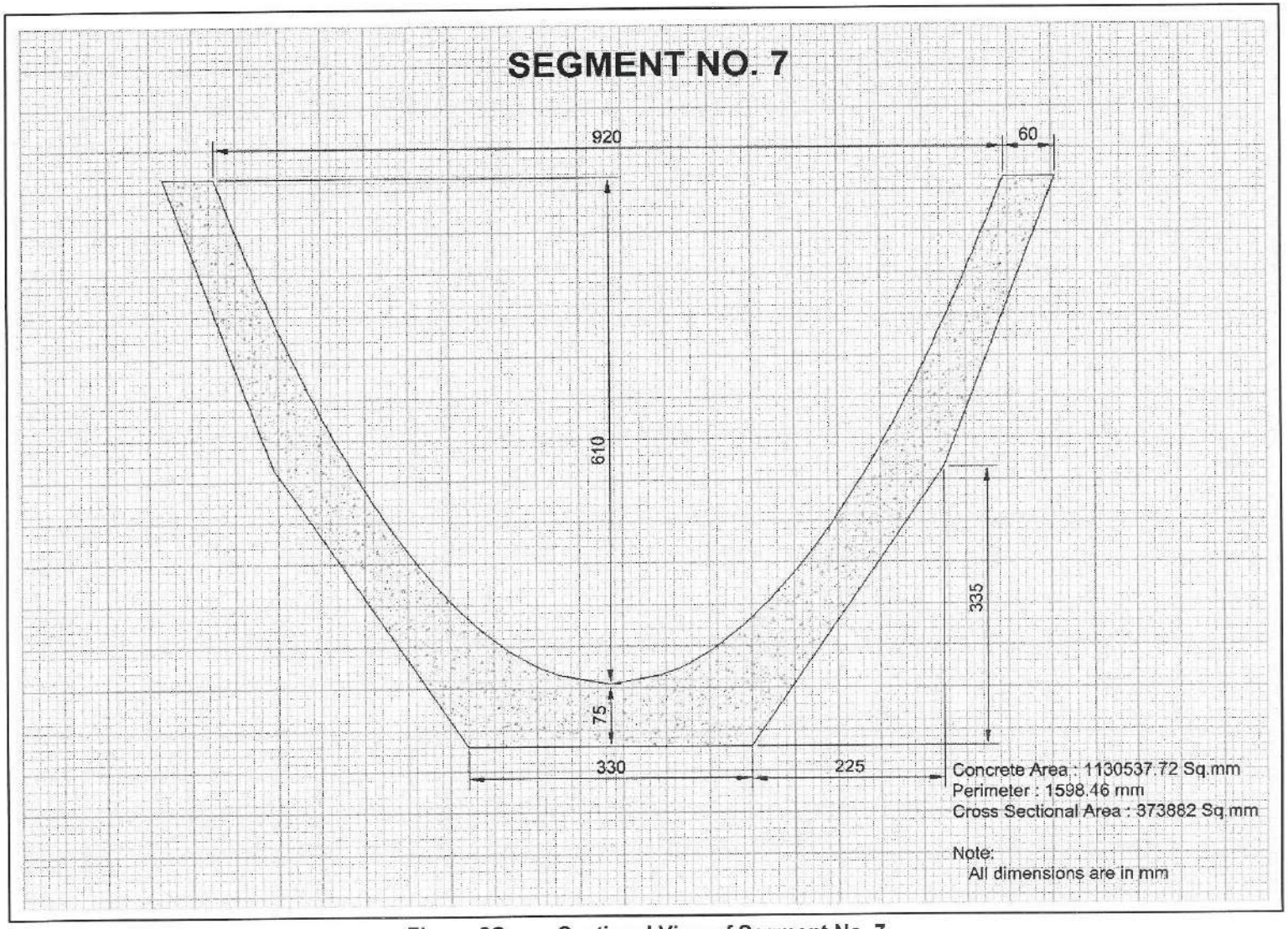


Figure-8Cross-Sectional View of Segment No. 7

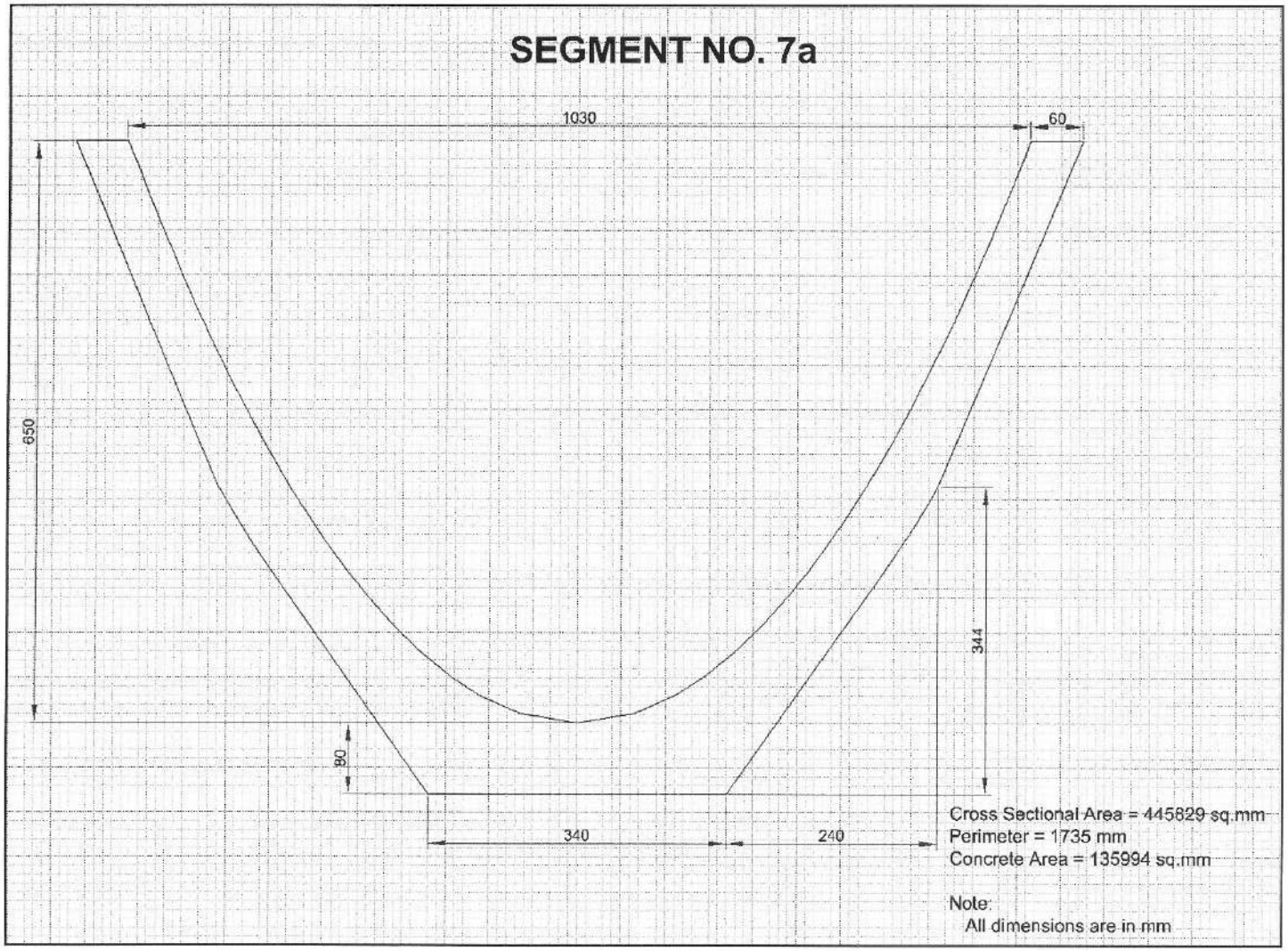


Figure-9Cross-Sectional View of Segment No. 7a

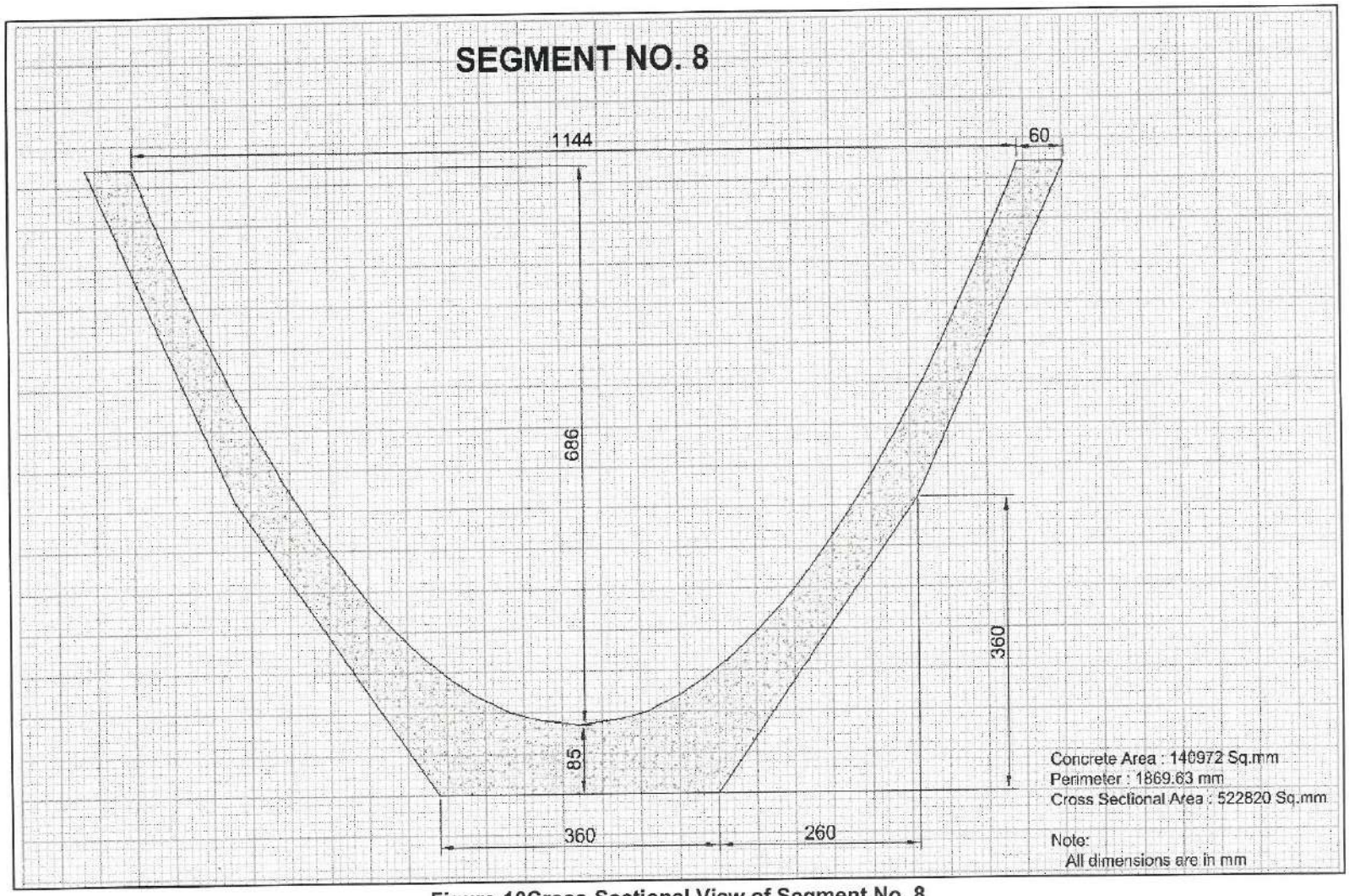


Figure-10Cross-Sectional View of Segment No. 8