

TECHNICAL BULLETIN NO. 1

SERIES OF 2022

GUIDELINES IN THE DESIGN AND CONSTRUCTION OF MULTI-CROP DRYING PAVEMENT (MCDP)





Republic of the Philippines
OFFICE OF THE SECRETARY
Elliptical Road, Diliman
1100 Quezon City

MEMORANDUM ORDER

No. 54
Series of 2022

SUBJECT : ADOPTION OF TECHNICAL BULLETIN NO. 1: GUIDELINES IN THE DESIGN AND CONSTRUCTION OF MULTI-CROP DRYING PAVEMENT (MCDP)

As the central engineering arm of the Department of Agriculture (DA), the Bureau of Agricultural and Fisheries Engineering (BAFE) is mandated to prepare, evaluate, validate, and recommend engineering plans, designs and technical specifications of agri-fisheries mechanization and infrastructure projects. Given these functions, the BAFE issues technical bulletin that will serve as guide of the DA bureaus, attached agencies and other DA implementing units in the preparation of their detailed engineering design and cost estimates.

Multi-crop drying pavement (MCDP) is a solar dryer where farmers can dry various agricultural crops such as rice and corn. It has a minimum area of 420 square meters (15 meters by 28 meters), with a thickness of at least four (4) inches. For this technical bulletin, a six (6) inches thick MCDP will be used as an improvement to the previous 4 inches thick design. It was observed that the earlier design of MCDP has higher rate of deterioration as it cannot withstand the continuous application of significant load exerted by large truck as well as agricultural machinery and equipment (e.g., farm tractor) within the structure. The design analysis for the proposed 6 inches MCDP will be discussed in detail in the Section VII of the attached technical bulletin.

This Memorandum Order shall take effect immediately upon approval.

Done this 20th day of June 2022


WILLIAM D. DAR, Ph.D.
Secretary *a*

Attached: a/s



DA-CO-OSEC-MO20220630-00013

A food-secure and resilient Philippines
with empowered and prosperous farmers and fisherfolk





TECHNICAL BULLETIN

No. 1

Series of 2022

**SUBJECT : GUIDELINES IN THE DESIGN AND CONSTRUCTION OF
MULTI-CROP DRYING PAVEMENT (MCDP)**

SECTION I. RATIONALE

As the central engineering arm of the Department of Agriculture (DA), the Bureau of Agricultural and Fisheries Engineering (BAFE) is mandated to prepare, evaluate, validate, and recommend engineering plans, designs and technical specifications of agri-fisheries mechanization and infrastructure projects. Given these functions, the BAFE issues technical bulletin that will serve as guide of the DA bureaus, attached agencies and other DA implementing units in the preparation of their detailed engineering design and cost estimates.

Multi-crop drying pavement (MCDP) is a solar dryer where farmers can dry various agricultural crops such as rice and corn. It has a minimum area of 420 square meters (15 meters by 28 meters), with a thickness of at least four (4) inches. This agricultural intervention is given to duly eligible recipients that comply with the necessary requirements, as prescribed in the DA Memorandum Order No. 50, Series of 2020, or the *Revised Guidelines in the Provision of Agricultural Production, Postharvest and Processing Machinery, Equipment, and Facilities*.

For this technical bulletin, a six (6) inches thick MCDP will be used as an improvement to the previous 4 inches thick design. It was observed that the earlier design of MCDP has higher rate of deterioration as it cannot withstand the continuous application of significant load exerted by large truck as well as agricultural machinery and equipment (e.g., farm tractor) within the structure. The design analysis for the proposed 6 inches MCDP will be discussed in detail in Section VII of this technical bulletin.

SECTION II. DEFINITION OF TERMS

Key terms used in this Technical Bulletin are defined as follows:

AGGREGATES – Granular material, such as sand, gravel, crushed stone, crushed hydraulic-cement concrete, or iron blast-furnace slag, used with a cementing medium to produce either concrete or mortar.

AREA COVERAGE - Space occupied by a flat surface and is measured in square meters.

AXLE LOAD – Portion of the gross weight of a vehicle transmitted to a structure or a roadway through wheels supporting a given axle.

ALLOWED VEHICLE - Type of vehicle allowed to pass thru or park at the surface of the MCDP.

BASE COURSE – (1) Layer of specified select material of planned thickness constructed on the subgrade or subbase of a pavement to serve one or more functions, such as distributing load, providing drainage, or minimizing frost actions; (2) Lowest course of masonry in a wall or pier.

COARSE AGGREGATES – Aggregate predominantly retained on the 4.75mm (No. 4) sieve or that portion retained on the 4.75mm (No. 4) sieve.

COMPACTION – Process of reducing the volume of voids in a material such as soil by input of mechanical energy. (*See also consolidation*)

CONSOLIDATION – Process of reducing the volume of voids, air pockets, and entrapped air in fresh cementitious mixture, usually accomplished by inputting mechanical energy.

CONCRETE – Mixture of hydraulic cement, aggregates, and water, with or without admixtures, fibers, or other cementitious materials.

CONCRETE COMPRESSIVE STRENGTH – Capacity of a material to withstand loads tending to reduce its size. It is measured in Megapascal (MPa).

CLEARING AND GRUBBING – Consist of clearing, grubbing, removing, and disposing all vegetation and debris as designated in the contract, except those objects that are designated to remain in place or are to be removed with consonance with other provision of this specification.

CONCRETE STRENGTH – Ability of concrete to resist force. For structural it can be defined as the unit force required to cause rupture. It is measured in Megapascal (MPa).

DETERIORATION – (1) Physical manifestation of failure of a material (for example cracking, delamination, flaking, pitting, scaling, spalling, and staining) caused by environmental or internal autogenous influences on rock and hardened concrete as well as other materials; (2) Decomposition of material during either testing or exposure to service.

EXCAVATION – Consists of roadway drainage and borrow excavation, and the disposal of material in accordance with required specification and in conformity with the lines, grades, and dimension shown on the plans or established by the Engineer.

EMBANKMENT – Consist of the construction of embankment in accordance with the required specification and in conformity with the lines, grades and dimensions shown on the plans or established by the Engineer.

FINE AGGREGATES – (1) Aggregates passing the 9.5mm (3/8 in) sieve, almost entirely passing the 4.75 mm (No. 4) sieve, and predominantly retained on the 75mm (No. 200) sieve; (2) Portion of aggregate passing the 4.75mm (No.4) sieve and predominantly retained on the 75mm (No. 200) sieve.

PAVEMENT – (1) Layer of concrete on such areas such as roads, sidewalks, canals, playgrounds, and those used for storage or parking. (2) Durable surface of a road, airstrip, or other similar area. Its primary function is to transmit loads to the sub-base (Item 200) and underlying soil.

PROJECT SITE – Land or property where the agri-infrastructure facility will be constructed.

PROGRAM OF WORKS – Total estimated cost of the project which covers the Civil Works Cost, Engineering Supervision and Administrative Overhead, Road Right-of-Way Acquisition Cost, Construction Contingency, etc.

REINFORCING STEEL BARS – Material used in reinforced concrete and reinforced masonry structure to strengthen the concrete under tension. Concrete is strong under compression, but weak in tension or in tensile strength.

STRUCTURAL CONCRETE – Material composed of concrete and reinforcing bars. The combination of two (2) materials (concrete and rebar) compensates with each other as the concrete is strong in compression but weak in tension, while rebar is relatively strong in tension but weak in compression.

SUBBASE – Layer in a pavement system between the subgrade and base course, or between the subgrade and the concrete pavement.

SUBGRADE – Soil prepared and compacted to support a structure or a concrete pavement system.

SECTION III. SCOPE AND COVERAGE

This technical bulletin shall serve as reference in the design and construction of MCDP for rice, corn, and other related crops implemented by the DA bureaus, attached agencies and corporations, regional field offices, and other DA implementing offices.

SECTION IV. OBJECTIVES

This technical bulletin aims to provide the guidelines in the modification of the MCDP design to increase the strength of a typical drying pavement.

SECTION V. SELECTION CRITERIA

Basic considerations in the identification of site and beneficiaries for the implementation of MCDP are listed below:

CRITERIA	REQUIREMENTS
Coverage Area	<ul style="list-style-type: none">▪ Minimum production area of 2 hectares for rice.▪ Minimum production area of 3 hectares for corn.
Beneficiaries	<ul style="list-style-type: none">▪ Registered Farmers Cooperative and Associations (FCAs) engaged in agricultural production and processing.
Site Requirements	<ul style="list-style-type: none">▪ Minimum lot/area of 420 square meters (m²) located near production areas, and accessible to service roads.▪ In case the minimum space requirement is not available, two (2) sites may be allowed provided that:<ul style="list-style-type: none">➤ Two sites are within the same barangay; and➤ Minimum area for each site is 210 m²▪ Lot/area not exposed to hazards.▪ With no or settled right-of-way issue.

SECTION VI. IMPLEMENTATION PROCEDURES

The following are the general procedures in the implementation of the MCDP:

A. EARTHWORKS

A.1. Clearing and Grubbing

- This item shall consist of the removal and disposal of all trees, stumps, roots, logs, shrubs, grass, weeds, fallen timber and other surface litter.

A.2. Excavation

- This item shall consist of roadway drainage and borrow excavation, and the disposal of material in accordance with DPWH specification and in conformity with the lines, grades, and dimensions shown on the plans or established by the Engineer.

A.3. Embankment

- This item shall consist of the construction of embankment in accordance with DPWH specification and in conformity with the lines, grades and dimensions shown on the plans or established by the Engineer.

A.4. Subgrade Preparation

A.5. Aggregate Subbase Course

B. COMPACTION TEST

- To increase the density or unit weight of soil a compaction test must be done prior to installation of rebars and concrete pouring. The material used shall follow DPWH Blue Book for highways Item 200 Table 200.1 Grading Requirement and shall be compacted using vibratory roller.

C. REINFORCING BARS

C1. Installation of Reinforcing Steel Bar (RSB)

- This item shall consist of furnishing, bending, fabricating and placing of steel reinforcement of the type, size, shape and grade required in accordance with DPWH specification and in conformity with the requirements shown on the plans or as directed by the Engineer.

D. CONCRETE MIX

D.1. Concrete Quality (Class A 3,000psi – 1:2:3:0.5)

- Quality of concrete plays an important role in the construction field as the concrete is the excessive element in any construction. The strength parameters such as durability, load bearing strength and resistance to environmental factor such as wind, snow, and water depends on the quality of concrete.

SECTION VII. DESIGN CONSIDERATIONS

For the design analysis, different types of vehicles and equipment were considered as load on the MCDP (see Figure 1). In the first scenario, a close delivery truck and elf truck without load are parked in MCDP. In the second scenario, the same vehicles in scenario 1 are parked on MCDP but with load. For the third scenario, a combine harvester, 4WD tractor, closed delivery van with load, and elf truck with load are parked on the MCDP. Using the Concrete Slab on Grade Analysis Calculator, the behavior of pavement was determined considering the total load of vehicles.

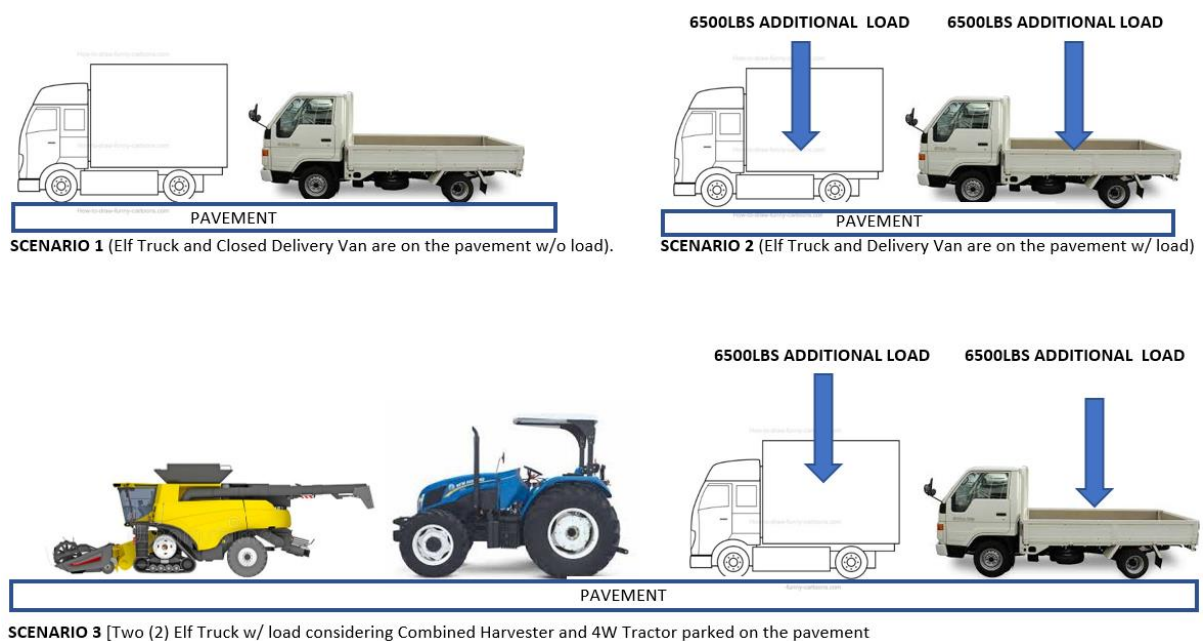


Figure 1. Multi-Crop Drying Pavement Design Analysis using 3 Scenarios

A. Design Analysis for 4" and 6" THK MCDP

Table 1 shows the different parameters use in the design analysis of the 4 inches (4") and 6 inches (6") slab thickness (thk) considering actual market information as well as data from the American Concrete Institute. Table 2 reflects the weight of the different vehicles used in analysis. These values were inputted in the Concrete Slab on Grade Analysis Calculator to ascertain the effect of varying loads to the strength of the pavement.

Table 1. Design Analysis Parameters for the 4" and 6" THK MCDP

PARAMETERS	4" THK MCDP	6" THK MCDP
Load Capacity	▪ 2,400.00 kgs	▪ 4,100.00 kgs
Conc. Strength	▪ 3,000 psi	▪ 3,000 psi

Unit Weight	▪ 150 psf	▪ 150 psf
Yield Strength	▪ 40,000 psi	▪ 40,000 psi

Table 2. Actual Load of the Different Type of Vehicles

VEHICLE	TOTAL WEIGHT		AXIAL LOAD (0.4WL)
	KGS	LBS	
1. 4WD Tractor	3,401.94	7,500.00	3,000.00
2. Combined Harvester	7,030.68	15,500.00	6,200.00
3. Elf Truck	7,257.48	16,000.00	6,500.00
4. Elf Truck with load	10,205.80	22,500.00	9,000.00
5. Delivery Van	7,257.48	16,000.00	6,500.00
6. Delivery Van with load	10,205.80	22,500.00	9,000.00
7. Trailer Truck	15,422.14	34,000.00	13,600.00

Based on the analysis, the 4" and 6" thk MCDP were subjected to different loading capacity from different type of vehicles listed in Table 2. Using the Concrete Slab on Grade Analysis Calculator (for Post Wheel Loading), the axial loads of vehicles were taken and applied to three (3) different scenarios as shown in Table 3. Results show that MCDP with 4" thk failed, while the 6" thk withstand the axial loadings of the different vehicles.

Table 3. Results of the 4" and 6" THK Design Analysis

SCENARIO	THK	VEHICLES	WEIGHT ¹	REMARKS ²
1	4	▪ Elf Truck w/o load	7,257.48 KGS	FAILED
	6	▪ Closed Delivery Van w/o load		PASSED
2	4	▪ Elf Truck w/ load	10,205.8 KGS	FAILED
	6	▪ Closed Delivery Van w/ load		PASSED
3	4	▪ Elf Truck w/ load	10,205.8 kgs	FAILED
	6	▪ Closed Delivery Van w/ load ▪ Combine Harvester ▪ 4WD Tractor		PASSED

In terms of the type of vehicle, analysis showed that the 4" thk MCDP could only sustain the axial wheel load of 4WD Tractor, and will fail for the following vehicles: (a) Elf Truck, (b) Closed Delivery Van, (c) Combine Harvester, and (d) Trailer Truck. On the other hand, 6" thk MCDP will not sustain the axial wheel load of the trailer truck.

¹ The vehicle with the largest axial weight in each scenario was considered in the analysis

² Results are based on Concrete Slab on Grade Analysis Calculator (For Post or Wheel Loading)

Table 4. Allowed Vehicles in 4" and 6" MCDP

PARAMETERS	4" THK MCDP	6" THK MCDP
Allowed Vehicle	<ul style="list-style-type: none"> ▪ 4WD Tractor 	<ul style="list-style-type: none"> ▪ 4WD Tractor ▪ Elf Truck ▪ Closed Delivery Van ▪ Combine Harvester
Not Allowed Vehicle	<ul style="list-style-type: none"> ▪ Elf Truck ▪ Closed Delivery Van ▪ Combine Harvester ▪ Trailer Truck 	<ul style="list-style-type: none"> ▪ Trailer Truck

B. Standard Minimum Test Requirement³

The minimum test requirement is essential in the implementation phase to assure that every material passed the required minimum standard and complied to the standard codes set by the American Society of Testing and Materials (ASTM).

Table 5. Standard Minimum Test Requirement

ITEM OF WORK	DESCRIPTION	MINIMUM TEST REQUIREMENT
102	Excavation	For every 1500 m ³ or less: 1-Grading Test 1-Plasticity Test (LL, PL, PI) 1-Compaction Test 1-California Bearing Ratio (CBR) For every 150 mm layer in uncompacted depth: 1- Field Density Test (FDT)
104	Embankment	For every 1500 m ³ or less: 1-Grading Test 1-Plasticity Test (LL, PL, PI) 1-Compaction Test 1-California Bearing Ratio (CBR)
105	Sub-grade Preparation	Same as Item 104
200	Aggregate Subbase Course	For every 300 m ³ or less: 1-P, Plasticity Test (LL, PL) 1-Compaction Test 1-California Bearing Ratio (CBR)

³ Based on DPWH – Standard Specifications for Highways Bridges Ports (Blue Book) - 2013

ITEM OF WORK	DESCRIPTION	MINIMUM TEST REQUIREMENT
		For every 150mm layer in uncompacted depth: 1-D, Field Density Test
404	Reinforcing Steel	Bar Reinforcement for Concrete for every 10,000 kg or less: 1-Bending 1-Tension 1-Chemical Analysis
405	Structural Concrete	A. Cement (Physical and Chemical Test) 1-Physical Test 1-Chemical Test B. Fine Aggregates B.1. For source not yet tested 1-Grading 1- Specific Gravity 1-Absorption 1-Unit Weight C. Coarse Aggregates C.1. For a source not yet tested 1-Grading 1-Specific Gravity 1-Absorption 1-Unit weight D. Water 1-Chemical Analysis (500ml), if source is questionable E. Steel Reinforcement E.1. 1 sample per 10,000kgs (1meter) 1-Bending Test 1-Tension Test 1-Quality Analysis or submission of Mill Certificate F. Concrete 1-Compressive Strength Test 1-Sample per 75 cu.m

Note: All material tests are based on set standard by ASTM

SECTION VIII. ITEM OF WORKS FOR 6" THK MCDP

The Item of Works is in line with the Department of Public of Works and Highways (DPWH) Department Order No. 143 "Revised Standard Pay Item List for Infrastructure Projects" while the quantity per item were based on the design of MCDP which has a length of 28 meters and width of 15 meters and a thickness of 6 inches.

Table 6. Item of Work for 6" THK MCDP

ITEM NO.	DESCRIPTION	QTY	UNIT
B.9	Mobilization/Demobilization	1.00	lot
B.5	Project Billboard	1.00	lot
100(1)	Clearing and Grubbing w/ Stripping	420.00	sq. m
102(1)	Excavation (Unsuitable)	126.00	cu. m
104(1)	Embankment (Suitable)	84.00	cu. m
104(2)	Embankment for topping, case 1	84.00	cu. m
105(1)	Subgrade Preparation	420.00	sq. m
200	Aggregate Subbase Course	42.00	cu. m
404(1.a)	Reinforcing Steel Grade 40	2,050.91	kgs
405(1.a1)	Structural Concrete (Class A 1:2:3:0.5)	63.00	cu. m

SECTION IX. CONCLUSION AND RECOMMENDATION

Based on the analysis using Concrete Slab on Grade Analysis Calculator (for Post Wheel Loading) for 6" thk MCDP, allowed vehicles are as follows: (1) 4WD Tractor, (2) Elf Truck, (3) Closed Delivery Van, and (4) Combine Harvester. Not allowed is the Trailer Truck.

Slab thickness of 4" failed based on calculation conducted as per "Design of Slab-on-Ground" - ACI 360R-06 - by American Concrete Institute (2006) and "Load Testing of Instrumented Pavement Sections - Improved Techniques for Applying the Finite Element Method to Strain Prediction in PCC Pavement Structures."

Therefore, adoption of **6" thickness** of slab and Concrete Class A 1:2:3:0.5 ratio with reinforcement is highly recommended.

SECTION X. REFERENCES

American Concrete Institute. (2006). *Design of Slabs on Ground - ACI 360R-06*. Farmington Hills, Michigan, United States.

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Charles Nunoo, Ph.D, Florida International University. (2002). *Stresses and Strains in Rigid Pavements*. Miami, Florida, United States.

Department of Civil Engineering, University of Minnesota. (2002). *Load Testing of Instrumented Pavement Sections - "Improved Techniques for Applying the Finite Element Method to Strain Prediction in PCC Pavement Structures*. Minneapolis, Minnesota, United States.

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Department of Public Works and Highways. (n.d.). *Standard Specifications for Highways, Bridges, and Ports (Blue Book)*. Manila, Metro Manila, Philippines.

Max L. Porter, Iowa State University. (2001). *Dowel Bar Optimization: Phase I and II*. Ames, Iowa State, United States.

Robert G. Packard, Portland Cement Association. (1976). *Slab Thickness Design for Industrial Concrete Floors on Grade (IS195.01D)*. Skokie, Illinois, United States.

For information and guidance



ENGR. ARIODEAR C. RICO

Director IV

Attached: a/s



REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL AND FISHERIES ENGINEERING
SUGAR CENTER, ANNEX II BUILDING EXTENSION, NORTH AVENUE, DILIMAN, QUEZON CITY

PROPOSED 6" THK MULTI-CROP DRYING PAVEMENT (MCDP)

GENERAL NOTES:

IMMEDIATELY AFTER ALL MATERIALS TO BE USED IN THE PROJECT HAVE PASSED THE MINIMUM TESTING REQUIREMENTS BASED ON THE STANDARD SPECIFICATIONS FOR DPWH. THE MANNER OF OPERATION IN THIS PARTICULAR PROJECT SHALL HAVE THE FOLLOWING SEQUENCE.

1. MOBILIZATION SHALL CONSIST OF MOVEMENT OF EQUIPMENT AND MANPOWER, MATERIALS, AND OTHER ITEMS THAT SHALL BE OF USE IN THE IMPLEMENTATION OF THE PROJECT.
2. ALL REINFORCED CONCRETE WORK SHALL BE DONE IN ACCORDANCE WITH ACT-318-89 AND STRUCTURAL STEEL WORK SHALL BE DONE IN ACCORDANCE WITH AISC SPECIFICATIONS.
3. IN THE INTERPRETATION OF THESE DRAWINGS, INDICATED DIMENSIONS SHALL GOVERN AND SIZES SHALL NOT BE SCALED FOR CONSTRUCTION PURPOSES.
4. THE CONTRACTOR SHALL COORDINATE WITH THE ENGINEERS OF THE IMPLEMENTING AGENCY FOR THE EXACT SIZE, DIMENSIONS, AND LOCATION OF THE PROJECT.

CONCRETE MIXES

1. UNLESS OTHERWISE INDICATED IN PLANS OR NOTED IN THE SPECIFICATIONS THE MINIMUM 28-DAYS CYLINDER COMPRESSIVE STRENGTH OF CONCRETE F'c SHALL

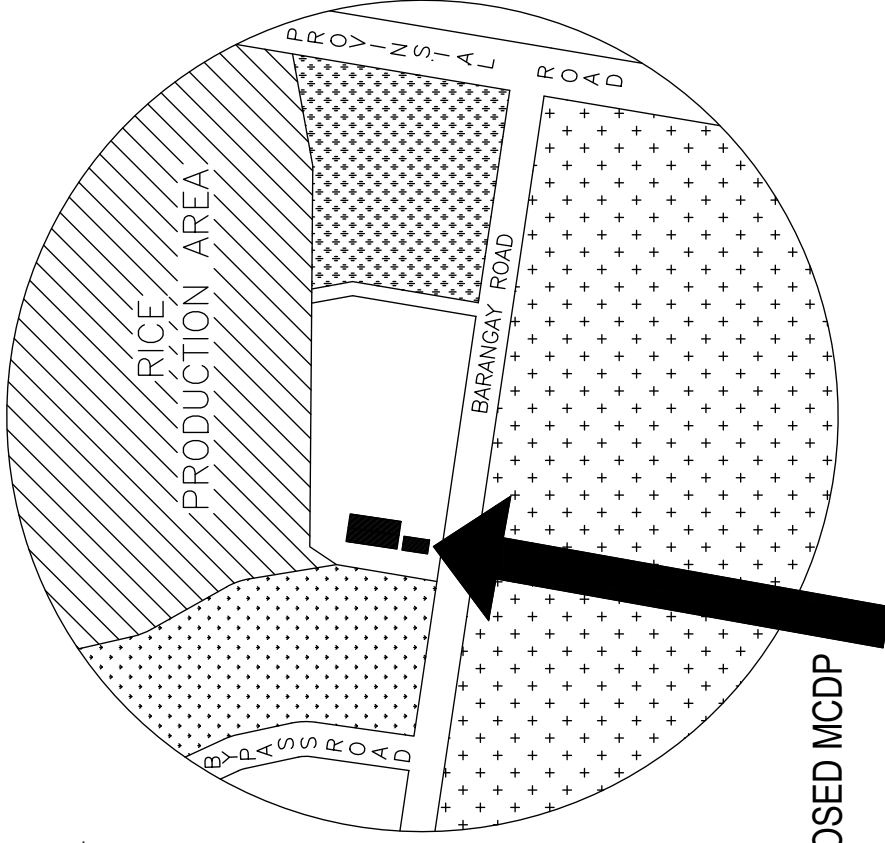
1. CONCRETE SLAB	21 MPa (3,000 PSI)	1 : 2 : 3 : 0.5
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REINFORCING STEEL BARS

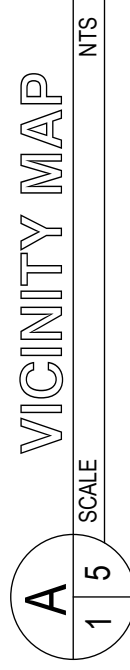
1. ALL REINFORCING STEEL BARS BE DEFORMED BARS CONFORMING TO THE SPECIFICATIONS OF PNS 49: 1986 (ASTM 615).
GRADE 40 (FY = 280 MPa) 12 MM DIA.

NOTES ON SLAB ON GRADE

1. ALL SLABS-ON-GRADE SHALL BE PROVIDED WITH A MINIMUM OF 150 MM THK.
2. UNLESS OTHERWISE NOTED, ALL BEDDED SLABS SHALL BE REINFORCED WITH 12MM BARS AT 500MM O.C EACHWAY.
3. THERE SHOULD BE A PROVISION OF CONCRETE SPACER TO PREVENT THE CORROSION OF REBARS



PROPOSED MCDP



PROJECT TITLE

PROPOSED DESIGN OF 6" THK MULTI - CROP DRYING PAVEMENT (MCDP)

SHEET CONTENT

GENERAL NOTES
VICINITY MAP

SHEET NO.

A-1

PROJECT LOCATION

1 of 5



A PERSPECTIVE
2 5 SCALE NTS



PROJECT TITLE

PROPOSED DESIGN OF 6" THK MULTI - CROP DRYING PAVEMENT (MCDP)

SHEET CONTENT

PERSPECTIVE

SHEET NO.

A-2

2 of 5

A

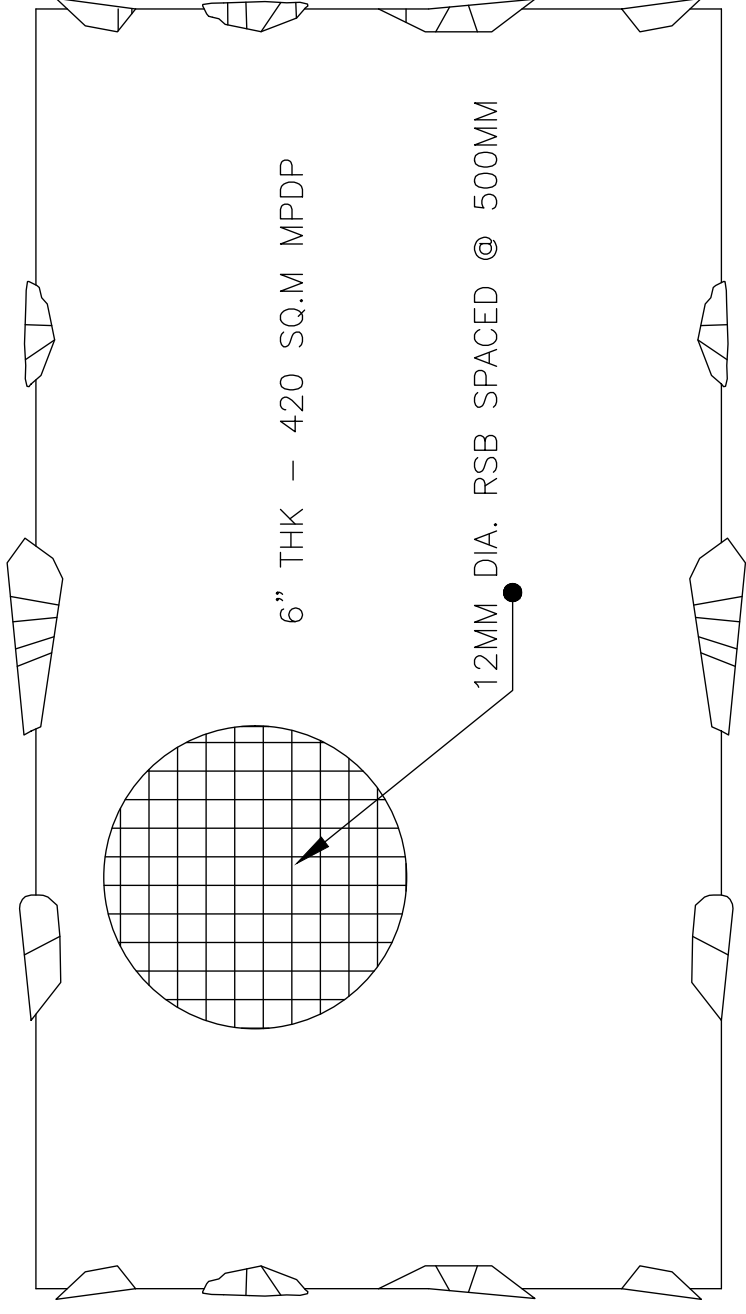
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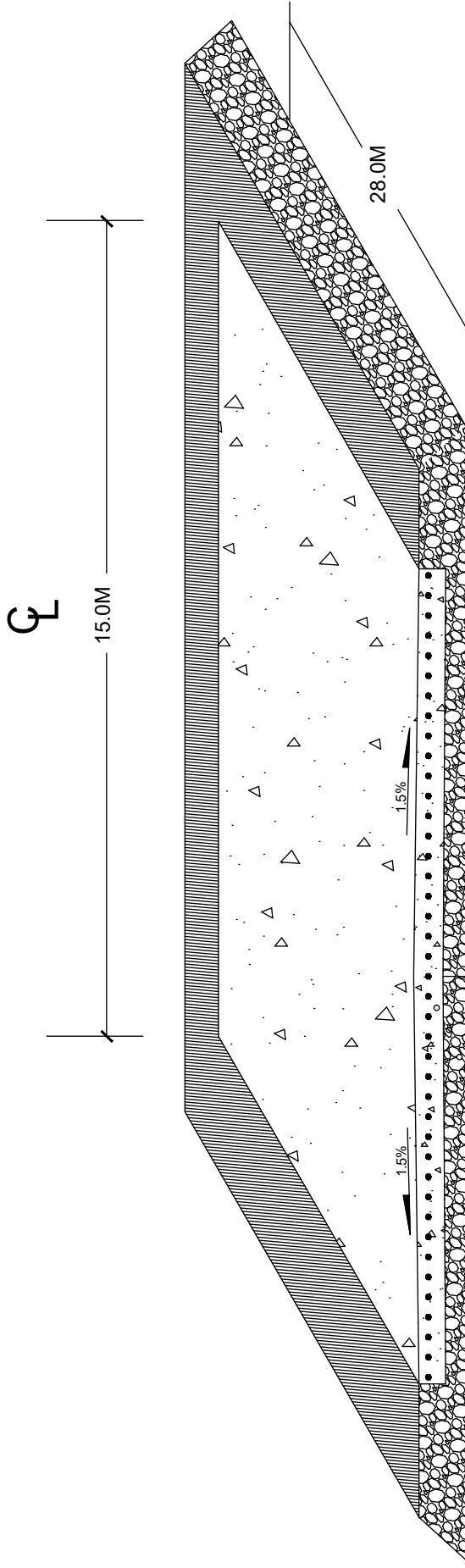


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SCALE

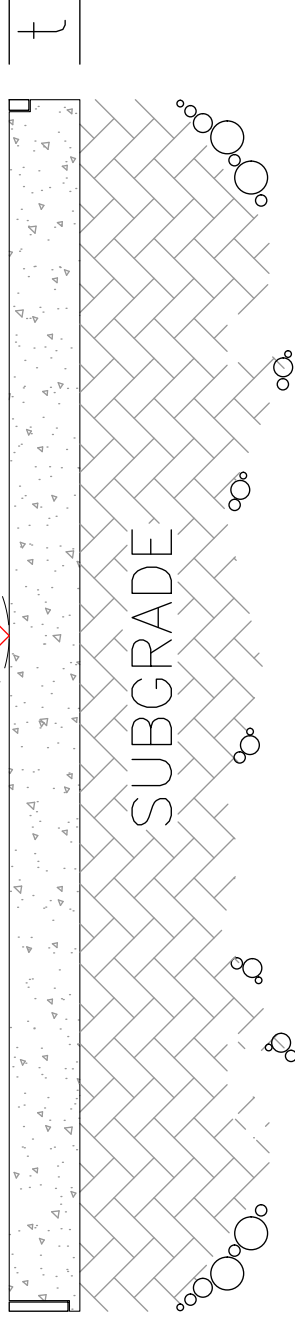
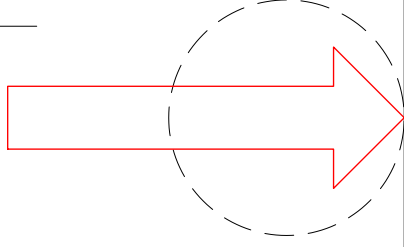
NTS

PLAN VIEW



A CROSS SECTION
 4 5 SCALE NTS

$$P = 0.4WL$$



FOR ASSISTANCE, PLEASE CONTACT

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