PIPE DISTRIBUTION SYSTEM FOR IRRIGATION

इनसिड - INCID

भारतीय राष्ट्रीय सिंचाई एवं जल निकास समिति

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INDIAN NATIONAL COMMITTEE ON IRRIGATION AND DRAINAGE

(Constituted by Ministry of Water Resources, Govt. of India)

NEW DELHI
SEPTEMBER, 1998

National level workshop on "Pipe Distribution System for Irrigation" held on 20th April 1995, and Inaugurated by Dr. M.S. Reddy, Secretary MOWR.

A Section of participants of National Workshop on "Pipe Distribution System for Irrigation Project" on 20th April 1995.

FOREWORD

Water is a precious commodity. However, its value is appreciated only in times of scarcity and non-availability. A comprehensive strategy has to be adopted for conservation and optimum utilisation of the available water resources in the State/ Country to meet its demand on sustainable basis. Attempts to improve the efficiency of irrigation systems at all possible levels are to be made in the case of major, medium and minor projects. Rehabilitation and modernisation of existing and ongoing irrigation systems, better operation and maintenance and more flexibility in regulation and scheduling of irrigation water are normally included under the development strategy.

Modernisation and rehabilitation does not necessarily mean only engineering measures such as modifications, improvement in storage, conveyance and distribution components of the project but also includes revised crop planning to suit soils in command areas, reappraisal of water requirements, frequency of water applications and other related aspects. However, efficient distribution of available water with minimum losses is the prime factor in the modernisation and rehabilitation of the projects. In this compilation, an attempt has been made to deal with the efficient distribution of water by gravity pipe distribution system.

In the context of improving irrigation water management, a well designed and carefully laid distribution network is very important. During the last 30-35 years, the underground pipe distribution system has come into vogue in States like Gujarat, Maharashtra, Karnataka, Kerala, Punjab and Uttar Pradesh. Under USAID Assisted project during 1988-92, a programme on underground pressurized rigid PVC pipe technology has been launched to cover about 46 Minor Irrigation Systems covering a total command area of 25,000 Ha. In Konkan Region, a number of completed MIS are proposed to be converted into pipe distributed systems under E.E.C. Assistance.

The Indian National Committee on Irrigation and Drainage (INCID) and its Special Committee on Construction, Rehabilitation and Modernisation under the assistance of one of its members, Shri K.D. Shinde, Superintending Engineer, Maharashtra Irrigation Department has brought out a State-of-the Art paper on Pipe Distribution System. Shri Shinde, and other members of the Special Committee, prepared the draft of the report. In the draft report, material from Technical Report No.15 "Pipeline Micro-Distribution" prepared under Water Resources, Management and Training (WRM&T) Project has also been used liberally. A brief summary of the draft report was widely circulated to all members of Special Committee, INCID members, WALMIs, State Irrigation Departments, CADAs for their suggestions/comments. The draft report was then discussed in a National Workshop in April, 1995 attended by the Ministry of Water Resources, Central Water Commission, INCID and its Special Committee members, WAPCOS, ICID, some eminent experts and other State and Central Officers. Shri Shinde later modified the draft report on the basis of the suggestions and recommendations of the workshop.

The document comprising 10 Chapters, aims a general study of pipe line distribution system and guidelines for adoption of pipe distribution system. In this document an attempt has been made to include literature review, necessity of system, selection of material for pipes, design consideration details, performances of system, cost economics, operation and maintenance, research and development aspects etc. Experiences and case studies of some projects have also been incorporated in the document.

Shri R.G. Kulkarni, Shri M.D. Pendse, Shri J.P. Kaushik, Shri A.R. Suryavanshi, Shri V.V. Bapat, Shri S.Y. Kulkarni and other members of the Special Committee who actively participated in discussions and preparation of this report have made significant contribution. Shri K.D.Shinde's contribution in preparing the comprehensive draft and later providing the revised report is indeed commendable and praiseworthy. I must also express my thanks to all INCID members, WALMIs, State Irrigation Departments, CADAs and Irrigation Management Organisation of Central Water Commission who have offered their views and valuable suggestions for improvement of the draft report and later on participated effectively in the National Seminar.

Shri P.B.Parabrahmam, Member Secretary, his colleagues in INCID Secretariat and Shri S.R. Agrawal, Engineer have indeed done a good job in bringing out this document. Shri Vimal Kumar Gaur, Data Entry Operator who diligently typed the report deserve to be complimented. Special thanks are due to Shri P.L. Diwan, Chairman and Managing Director, WAPCOS (India) Limited for his keen interest and valuable suggestions, from time to time besides providing all the infrastructural facilities to the INCID Secretariat.

It is hoped that this document would serve as an useful State-of-the Art paper to the administrators, planners, designers, implementation authorities and lastly forming community and will facilitate greatly in promotion of pipe distribution systems in the country.

Place : NEW DELHI

Date : Sept., 1998

(Z. HASAN)
Chairman, INCID &
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PIPE DISTRIBUTION SYSTEM FOR IRRIGATION

EXECUTIVE SUMMARY

1.1 Nature has endowed our country with abundant Water Resources. However, due to limitations of topography, geology, physiography, dependability, quality and the present state of technology, only a part of available water resources can be utilised. The utilisable water for irrigation is further limited considering other competing demands for domestic, industrial uses, recreational activities etc. It is a matter of great concern that this is happening at a time when there is an increased demand for various agricultural products due to phenomenal growth in the population. The need of the hour is, therefore, to maximize the production per unit of water, besides effecting utmost economy in water use for agriculture.

1.2 The major thrust area at present has been to improve the efficiency of irrigation systems, which includes rehabilitation and modernisation of existing and on-going irrigation systems by better operation and maintenance and more flexibility in regulation and scheduling of irrigation water. Modernisation and rehabilitation does not necessarily mean only engineering measures such as modifications, improvement in storage, conveyance and distribution components of the project but also includes revised planning of cropping pattern for efficient use of water. However, efficient distribution of water is the prime linking factor in the modernisation and rehabilitation of the projects.

1.3 Pipeline distribution system, in the context of irrigation water supplies is a network of piped system that transports water over long distance all over the command area. The relative advantages and disadvantages of the pipe distribution system for irrigation water management are as under :

ADVANTAGES :

(i) Little loss of farm land compared to open channel network
(ii) Virtually no water loss
(iii) Prevention of waterlogging and weed growth
(iv) Low maintenance cost
(v) Better control
(vi) Less seepage loss
(vii) No evaporation loss
(viii) Flexible to operate
(ix) No soil erosion

(x) Installation is easy

(xi) Long life

(xii) Diseases and pest problems are minimum

(xiii) Economy in laying as no culverts or other structures are required.

(xiv) Can be clubbed with advanced techniques/pressurised irrigation method.

DISADVANTAGES/LIMITATIONS :

(i) Greater initial investment.

(ii) Corrosion hazards

(iii) Require high skill in design and installation

(iv) Not fit for water which contains large amounts of sediment.

2.1 Pipes have been used for many centuries for transporting fluids. First pipe line for water distribution through gravity flow was laid down in ancient Rome. In 1582 pumps were introduced for pipe line distribution in London. Besides the use of pipe line to transport water for municipal supply and sewerage, pipelines are most common means for transporting gasses and oils over long distance. Pipe lines are now used in distribution of irrigation water.

2.2 Various material suitable for pipeline have been developed starting from bamboo pipeline to cast iron, steel, asbestos, cement, reinforced and pre-stressed concrete, polyethelene low density and high density, reinforced plastic, fibre glass, fibre reinforced plastic, etc. Selection of pipeline material is based on various factors such as required carrying capacity, ability to resist internal and external pressure, life, durability, maintenance etc but the most important factor is economy as pipes represent a large proportion of huge capital involved in water distribution network.

3.1 Pipeline distribution system could be adopted in situations where :

(a) Water availability is limited and command is extensive

(b) There is steep topography/uneven terrain.

(c) Heavy seepage losses

(d) Adoption of modern techniques is contemplated.

3.2 Pipeline distribution system needs to be designed very carefully to transport a required quantity of water efficiently. If the pipe lines are too small in diameter, pumping costs are increased and the capacity of the system may be severely limited. On the other hand, pipelines larger than necessary add to the cost of system and may cause uneven flow. All joints and connection are to be constructed to withstand the maximum designed working pressure without causing leakage and should have the inside of the line free of any obstruction. Necessary control structures such as stands, valves and outlets, measuring devices etc are to be installed adequately for effective and efficient functioning of the system.

4.0 For a proper and effective pipeline system, perfect planning and design is necessary. For this purpose elaborate survey and collection of data are required. Mapping depicting all major details i.e. buildings, roads, rail tracks, lakes, ponds, irrigation structures and drawings showing area to be irrigated, lay out of pipeline locations of fittings etc. are important tools for successful laying of any pipe distribution system. For small command, plans are prepared to the scale of 1:1000 but for a larger command,scale of 1:4000 may be satisfactory.

5.0 Various methods viz. Net investment and Net benefit method, and ERR calculation are used for calculation of BC Ratio for pipe distribution system. The working group report of Ministry of Irrigation "Guidelines for Preparation of detailed Project Report of Irrigation and Multi-purpose Projects" may have to be referred for calculation of BC ratio.

6.1 The pipe specifications and construction methods should conform to ASTM/ BIS codes. The design water velocity in a pipe line when operating at system capacity should not exceed 1.52 m/sec. Various fittings and accessories such as check valve, pressure relief valve, air release and vaccum relief valve, etc. should also be provided in the system.

6.2 The pipe line should be throughly and completely tested for pressure, strength and leakage before backfill operations are undertaken and the entire length of the pipe line should be inspected while the maximum working pressure is maintained. In order to achieve desired progress of construction work within stipulated time, the PERT and CPM charts should be prepared and used.

7.1 Operation should be such that the pipeline system works with full efficiency for wide range of variations in discharge. Sudden closing and opening of valves should be avoided. For efficient operation, measurement of discharge at various points will be the controlling factor.

7.2 For proper maintenance, keeping sufficient stock of spares, timely inspection to locate leakages, observation of discharges, security and protection of pipe lines are the main guiding factors.

An operational manual consisting of guidelines for operation system layouts, precautionary measures, the responsibilities of operation staff and instructions for various emergency procedures should be prepared.

8.0 Research on pipes should be continued for betterment of the pipeline system of distribution. There is a need for development of software for optimisation of sizes of pipe and minimising the losses. Various flow measuring devices for velocity, discharge, pressure and head should be evolved.

9.1 During the last 30-35 years, pipe distribution system has developed in a rapid way in States such as Gujarat, Himachal Pradesh, Maharashtra, Madhya Pradesh, Karnataka, Kerala, Punjab and Uttar Pradesh especially under commands of tubewells and minor irrigation projects including lift irrigation projects. Some case studies of pipe distribution systems under taken in various States are presented in Chapter-9. Buried Pipe Irrigation System has been adopted for Punade and Wava Minor Irrigation schemes in Konkan region under USAID assistance. The cost per hectare for Wava and Punade for pipe distribution system works to Rs 32,800/- and 28,800/- per ha respectively.

In Konkan region, a number of completed minor irrigation schemes are proposed to be converted into pipe distribution system under E.E.C. assistance. The details regarding Gadi Galtar and Khor Tank Project in Madhya Pradesh and Giri Projects in Himachal Pradesh are also furnished.

10.1 Considering the scarcity of water, it is recommended that irrigation in command shall be popularised through pipe line distribution system.

10.2 It is recommended that in case of excessive seepage patches and trouble of burrowing animals, the pipe line distribution system should be preferred. Canal falls and steep gradients are more favourable for introduction of pipe line distribution system. This system should also be preferred where land cost is high and farmers are reluctant for sparing the valuable land.

10.3 For judicious use of water, the modern techniques namely sprinkler and drip irrigation can be encouraged. The pipe line distribution system would be more suitable for implementation of advance techniques.

10.4 Advanced material like PVC - RIBLOCK, Fibre Glass - RP is more suitable because of low cost, light in handling and smooth finishing and easy repair facility and hence its use can be encouraged.

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ABBREVIATIONS

ABS	-	Acrylonitrile Butadine Systems
A.C.	-	Asbestos Cement
A.P.M.	-	Automotic proportion Module
ASTM	-	American society for Testing and Materials
B.C.Ratio	-	Benefit Cost Ratio
B.I.S.	-	Bureau of Indian Standards
CAD	-	Command Area Development
CPM	-	Critical Path Method
Cumec	-	Cubic meter per second
C.I.	-	Cast Iron
EEC	-	European Economic Community
ERR	-	Economic Rate of Return
Ft	-	Feet
Ft/s	-	Feet/Sec.
G.L.	-	Ground level
G.P.M.	-	Gallons per minute
H.R.	-	Hard Rock
HDPE	-	High Density Polyethylene
HGL	-	Hydraulic gradient line
I.S.I.	-	Indian Standard Code for Information
Ips	-	Litre per second
in	-	inch
K Pa	-	Kilo Pascal
Km.	-	Kilometers
MIS	-	Minor Irrigation Scheme
Mm^3	-	Million Cubic Meter
m	-	meter
mm	-	milimeter

Mcft	-	Million Cubic feet
PE	-	Polyethylene
PH	-	Negative exponent to the base 10, of Hydrogen Ion concentration per litre of water
PERT	-	Programme Evaluation & Review Technique
Psi	-	Pounds per Square inch
PVC	-	Poly Vinyl Chloride
RCC	-	Reinforced Cement Concrete
RWS	-	Rotational Water Supply
S.R.	-	Soft Rock
WSC	-	Washington State College

PIPE DISTRIBUTION SYSTEM FOR IRRIGATION

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CHAPTER - 1

INTRODUCTION

1.1 NECESSITY OF PIPE DISTRIBUTION SYSTEM

1.1.1 With the increasingly greater demand on a limited water supply in many parts of country, there is an urgent need for its efficient utilization by reducing losses at various points in the irrigation system. Within the farm area, water losses can be greatly reduced by having proper system for distribution of irrigation water. A pipeline distribution system offers such a possibility.

1.1.2 Generally the system is buried underground and fixed permanently. However, overground and portable systems are also in use, specially for operating sprinkler and drip irrigation system. For surface irrigation methods where high heads are not required, the pipeline distribution system merit consideration since it is essentially a low pressure one, also known as 'open or semi - closed system', which is open to the atmosphere and where the operating pressure seldom exceed 5-6 m. Pressure irrigation systems, such as sprinklers and drips, operate on much higher pressures, generally greater than 25 m. and therefore, it is necessary to have a high pressure pipeline distribution system for them. More emphasis is given to the low pressure irrigation system in this state of art paper.

1.1.3 In the context of improving irrigation water management below the outlet a well designed and carefully laid distribution network of field channels is very important. In India, open field channels are generally in use in the canal command area. Both lined and unlined channels are used to deliver water to the farmers' fields.

1.1.4 If the water distribution system is well operated, many other important management objectives can be satisfactorily realised and high returns obtained. In the case of conventional irrigation methods i.e., open channel distribution system, the evaporation losses, seepage losses and malpractices cannot be totally eliminated even with full control and efficient management of the system. However, with pipe distribution system, these parameters can be substantially controlled and minimised to reduce the adverse effect on irrigation efficiency.

1.2 DEFINITION OF PIPES AND PIPELINES

1.2.1 Pipe is a tube used to transport liquids and gases from one place to another. Huge pipes bring water to the city from wells, lakes or other sources of supply. A vast network of pipes then distributes the water to homes and to each sink, toilet and other water fixtures in the house. Another network of pipe carries the wastewater away from these fixtures through drains and sewer pipes.

1.2.2 Pipeline is a system of pipes that transports certain substances over long distances. Pipelines play an important role in the operation and the economy of modern communities. They carry most of the water used in homes, commercial establishments and industries and transport natural gas, Petroleum and petroleum products such as gasoline, kerosene and diesel fuel. They also carry industrial waste and sewage and coal particles, iron ore and limestone in slurry form used for industrial purposes.

1.2.3 The pipeline distribution system can be used for conveyance of water from main reservoir to the field application point. In case of high-value systems, i.e., sprinkler and drip systems, the field application is also through pipes and specially developed micro-tips/emmitters.

1.3 KINDS OF PIPELINES.

There are three main kinds of pipelines (1) Gas pipelines (2) liquid pipelines and (3) solid pipelines.

1.3.1 Gas Pipelines

Gas pipelines carry mainly natural gases. Pipelines called gathering lines transport the gas from the well to processing plants. The processed gas is then fed into transmission pipelines which carry it to cities and towns. There, the gas is delivered to consumers through distribution lines. There are two kinds of distribution lines - mains and service lines. Mains are large pipes connected to transmission pipelines. Service lines are small pipes that branch out from the mains. They carry the fuel sold by utility companies to homes, offices, factories and other consumers.

1.3.2 Liquid Pipelines

Liquid pipelines carry mainly petroleum products and water. In transporting petroleum, gathering lines take the oil from the well to trunk pipelines. Some trunk lines move the oil directly to refineries. Others take it to shipping points for delivery to the refineries by tankers, barges, railroads, cars or trucks. The refineries use the petroleum in making gasoline lubricating oil and other products, which are carried to market areas through product pipelines. Water supply pipelines are used to carry water from source to individual houses or irrigation farms for different purposes.

1.3.3 Solid Pipelines

Solids in slurry form or in containers are also being pumped through pipe lines on ever increasing scale.

1.4 ADVANTAGES & DISADVANTAGES OF PIPELINE SYSTEM IN GENERAL

There are many advantages of pipeline transport compared with other modes of transport such as roads, railways, waterways and air. The advantages are :

1) Pipelines are often the most economic form of transport (considering either capital costs, running costs or overall costs).

2) Pipeline costs are not very susceptible to fluctuations in prices since the major cost is the capital outlay and subsequent operating costs are relatively small.

3) Operations are not susceptible to labour disputes as little attendance is required. Many advanced systems operate automatically.

4) Being hidden beneath the ground, a pipeline will not mar the natural environment.

5) A buried pipeline is reasonably secure against sabotage.

6) A pipeline is independent of external influences such as traffic congestion and the weather.

7) There is normally no problem of returning empty containers to the source.

8) It is relatively easy to increase the capacity of a pipeline installing a booster pump.

9) A buried pipeline will not disturb surface traffic and services.

10) Way for laying the pipelines are usually easier to obtain than roads and railways.

11) The accident rate per ton - km. is considerably lower than for other forms of transport.

12) A pipeline can cross rugged terrain difficult for vehicles to cross.

There are of-course disadvantages associated with pipeline systems and they are:

1) The initial capital expenditure is often large, so if there is any uncertainty in the demand, some degree of speculation may be necessary.

2) There is often a high cost involved in filling a pipeline (especially long fuel lines).

3) Pipelines cannot be used for more than one material at a time (although there are multiproduct pipelines operating on batch basis).

4) There are operating problems associated with the pumping of solids, such as blockages on stoppage.

5) It is often difficult to locate leaks or blockages.

1.5 IRRIGATION PIPELINES

Three types of on-farm irrigation pipelines are generally used.

i) Completely portable surface system, where water enters the line at the supply a well, reservoir or open channel turn out and the water is applied to the field from the open end of the pipeline, or from gated outlets distributed along the line.

ii) A combination of buried and surface pipeline through one or more risers, and

iii) The completely buried system, generally used for border or basin irrigation, where the need for surface pipe is eliminated. Water is released into the portion of the field to be irrigated form risers on the buried pipeline.

1.5.1 Advantages and Disadvantages of Underground Pipeline System for Irrigation

Advantages :

1) Little loss of farm land, as almost the entire system is buried - as a result, no significant amount of productive farm area is lost to crop production, as is the case in an open channel network.

2) Virtually no water loss - a pipeline system is essentially water tight, with no evaporation and seepage losses during transmission as a result there are water savings and less pumping cost.

3) Less seepage losses also reduces drainage problems.

4) Labour saving - the control of water is simple and usually requires 25-50% less labour per unit area of irrigation than that required with open channel.

5) Permanence - a pipeline properly designed, made of good quality materials, and well constructed has a long life span.

6) Ease of conveyance - one can take the most direct route from water supply to outlet points. This is particularly important in undulating land. Water can be transported across a depression, or boosted uphill, which is not possible with open channels, unless an elaborate structure is built.

7) Low maintenance cost - generally maintenance costs are low, as the system is buried, on the other hand earthen channels have to be maintained continuously.

8) No channel block problems - there are no channels to become choked with weeds to hinder flow. Weeds can also harbor harmful insects. In addition, weed seeds which can be transported to fields in open channel are eliminated.

9) Better control - better and easier control of the flow of water means that more efficient irrigation is possible.

10) No hindrance to equipment - there are few obstacles to hinder the movement of agricultural equipment and farm transport. This is an important feature where fields are small.

11) Full and effective control of irrigation water resulting into taking up of crop diversification such as horticulture, vegetables and other cash crops such as groundnut etc.

12) No evaporation losses.

13) Long durability of system.

14) A relatively permanent, trouble free system with long term benefits on investment.

15) Possibility of introduction of pressure irrigation methods such as sprinkler and drip. These new concepts have also made the provision of pipe distribution network, a necessity.

16) No culverts or other structures such as falls are required. Buried pipelines are taken in straight line so considerable saving in length results in considerable economy.

17) Easy to instal and lay and therefore construction period is reduced.

18) Excavation limited to one meter plus diameter of the pipe, hence less earthwork.

19) High-returns because of assured and controlled water supply.

20) Crop diversification to derive maximum benefits from irrigated farming practices.

21) Scheduling of irrigation based on crop water requirement can be efficiently implemented.

22) Farmers at tailend reaches can get enough assured irrigation water.

23) As time can be saved the realisation of the benefits from the capital investments are materialised quickly and this boosts the economy.

Disadvantages:

1) Less advantage with large flow, as the cost of pipe lines increases faster with capacity than does the cost of open channels. The net economy of pipeline varies with the value of land, frequency of irrigation and cost of irrigation labour. Thus, it is impossible to set flow limits above which ditches might have some advantages over pipelines.

2) Greater initial investment in pipelines, but in the long run pipelines are economical, because of savings in water, labour,maintenance, land and permanence of installation.

3) Saline conditions require selection of the proper type of material, as concrete pipes are subject to deterioration.

4) Earthquake damage - although the risk is very low, there are a few examples of the underground pipelines getting damaged.

5) Pipelines are not desirable for irrigation water transmission if the irrigation supply contains large amounts of sediments and the flow conditions in the line allow the sediments to settle out and reduce the carrying capacity of the line.

1.6 COMPARISON WITH CONVENTIONAL IRRIGATION SYSTEM

The underground pipeline system provides effective control on the distribution of water for the crops leading to achievement of diversification of crop pattern namely horticultural, cash crops and other than traditional crops. Two operating systems namely, one rotational water supply (R.W.S) and the other on demand scheduling are technically reliable to ensure water at farm gate.

1.6.1 Rotational Water System

In rotational method, water is delivered at a fixed time on pre-arranged schedule. Farmers in group are assured of the water supply at each farmgate. The water distribution shall be by rotation in sequence assured at each farmgate by the implementing organisation.

1.6.2 On Demand Scheduling

On demand scheduling, the farmers have to apply for water atleast 48 hours in advance. The supply of main pipeline and lateral will be fully charged at designed discharge. The demands are adjusted to suit 7 days working period since the system is to be designed to complete all irrigation in a span of 7 days. Demand of a group or individual irrigators under the chak is considered.

Demand will be received for each rotation for a seasonal crop and horticultural or cash crops.

In the conventional system of canal the efficiency attainable ranges between 45 to 50% whereas in the pipe distribution system, it can be increased upto 70%.

This technology has brought about a revolution professionally, environmentally and socially to mark spontaneous response from the farmers for an extensive irrigated agriculture in case of ADIVASIS under USAID assisted Madhya Pradesh Irrigation Project.

2.6.4 The pipeline distribution system is ideally suited for the Konkan Region of Maharashtra State., There is vast potential for developing horticulture in the Konkan Region. However, the present system of open channel flow does not permit the farmer to grow anything other than paddy. With the assured and controlled supply of water by means of pipeline distribution scheme, this limitation is now removed and with active participation of the farmers this project is bound to prove very successful.

2.6.5 The entire campus area of Tamil Nadu Agricultural University, Coimbatore of about 750 acres were laid with underground pipeline connecting different points of various farms by intergrid. The total dimensions were based upon the design and the system is functioning very efficiently.

Coimbatore and Salem districts from Tamil Nadu are the regions where the agriculture mainly depends upon wells and the areas are also of mainly undulated topography. Generally, the farmers having more awareness about agricultural technologies are active to do intensive agriculture by the underground pipeline. However, there are examples of abandonment of underground pipelines due to non availability of water in the wells owing to the excessive groundwater exploitation beyond replenishable limit by recharge.

2.6.6 In Rajasthan, Jhalawar district has the credit for the successful lift irrigation (Community) Schemes with pipe distribution systems.

CHAPTER - 3

PIPE DISTRIBUTION SYSTEM - QUALIFYING CRITERIA AND VARIOUS REQUIREMENTS

3.1 GENERAL

3.1.1 In India, mainly reinforced cement concrete (NP2 Class) and cement concrete (NP1 Class) pipes were originally used. These pipes have been used in low pressure systems, which are open to the atmosphere. However concrete pipes are very bulky and pose problems in transport as well as in laying.

3.1.2 In recent years, the use of plastic pipes has been increasing rapidly for irrigation distribution networks. These pipes are light weight and thus easy to handle and lay in the field, also they are leak proof. Ultimately, plastic pipes are likely to replace the concrete pipes. Plastic pipes are used for both low pressure and high pressure systems.

3.2 QUALIFYING CRITERIA

3.2.1 The pipeline distribution system shall be adopted when there is

a. Limited water availability and extensive command.
b. The steep topography where canal system is very expensive.
c. Heavy and uncontrolled seepage losses.
d. Uneven ground and undulated terrain.
e. Adoption of modern techniques for future development.
f. Farmers responses and acceptability.
g. Need for crop diversification.
h. Availability of adequate fund.
i. When high returns are expected.
j. Timely availability of material, technology, labour, maintenance techniques, construction technology etc.
k. The pipeline (gravity flow) is generally feasible in the case of sloping topography having ground slopes steeper than 1 to 500.

3.3 PIPE MATERIALS

3.3.1 Pipe material shall be judiciously selected from the point of view of durability, life and over all cost which includes, besides the pipe cost, the installation and maintenance costs necessary to ensure the required function and performance of the pipeline throughout its designed life time.

design capacity. All fittings such as couplings, reducers, bend tees and crossings should be made of material that is recommended for use with the pipe and should be installed in accordance with the recommendations of the manufacturer. Where fittings made of steel or other metals subject to corrosion are used in the line, they should be adequately protected by wrapping with plastic tape or coating with high quality corrosion preventives. Where plastic tape is used, all surfaces to be wrapped should be thoroughly cleaned and then coated with a primer compatible with the tape.

3.6 DESIGN REQUIREMENTS OF UNDERGROUND PIPELINE IRRIGATION SYSTEM.

An underground irrigation system must be properly designed to handle the required flow throughout the system efficiently. If pipelines are too small in diameter, pumping costs are increased and the capacity of the system may be seriously limited. On the other hand, pipelines larger than necessary add to the cost of system and may cause uneven flow. Control stands must be high enough to allow sufficient operating head for the pipe lines. Stands higher than necessary may permit high heads of water to build up, leading to excessive line pressure.

3.6.1 In executing the pipeline distribution schemes in the minor irrigation command areas where the open channel system is already in operation, the Main Pipeline replaces the main canal. This avoids the issue of additional land acquisition which is a very critical issue due to very small land holdings (0.2 to 0.5 ha per family) in regions like Konkan. In new schemes there is a flexibility in choosing the alignment of the main pipeline.

For a given size of an individual pipeline distribution systems the discharge ranges between 130 lps to 500 lps and hence the pipe diameters generally lie in the range of 300mm to 900mm. The length of main pipe line is also about 3 to 5 km. Different types of pipes such as RCC, PVC, PVC Ribloc^R can be used.

The design pressures are in the range from 5 m to 25 m. Therefore, in general, PVC Class 2.5 pipes can be used conveniently. However in hilly terrain, operating pressures in excess of 2.5 kg/cm^2 are not unusual. However, in such cases,use of higher class pipes or steel pipes has to be considered. The pressures in the main pipe line of a minor irrigation scheme is generally upto 10 m and hence RCC pipes of NP2 class are used. For higher heads P1 Class pipes are used. Since the main line generally follows the alignment of the canal (generally along contour), head drop along the main line is less (about 1 to 5 m loss of head). However, quite frequently there are a number of falls along the alignment and hence the main line can be subjected to large static pressures and hence a P1 class pipe needs to be considered. The allowable heads under each class of pipe may be seen in Table - 1 and Table - 2 for RCC and PVC Pipes respectively. In case where the pressures are higher than 25 m, float valves are deployed to break the pressure to a lower value so that the conventional RCC, PVC Pipes can be used. PVC Ribloc[R] pipe are formed at site by spirally wound PVC ribbed strips. These are generally available in diameters from 150 mm to 1000 mm and in required and manageable lengths. These pipes are light weight. The working pressure depends on the diameter and the type of profile of the strip, but is in the range of 0.5 to 2.25 kg/cm^2.

Table - 1
Allowable Heads for Commonly used RCC Pipes

Sl. No.	Class of Pipe	Test Pressure	Working Pressure	Place of Use
1.	NP2	7 m	4.67 m	For low water head and low superimposed external load
2.	NP3	7 m	4.67 m	For low water head & medium superimposed external load
3.	P1	20 m	13.33 m	For meduim water pressure
4.	P2	40 m	20.00 m	For high water pressure

The Main Pipeline is provided with branch outlets along its length so as to feed the distribution system of each chak. For controlling the flow of water, sluice valves or Tee Valves are provided. Similarly, along the main pipe itself sluice valves/Tee Valves are required to be provided at suitable distances (1 km to 1.5 km) to stop the flow in case of emergency. A sluice valve commonly used on water supply lines is standardised (IS:780 & IS:2906 of 1984) for operating at comparatively high pressures (10 kg/cm^2). Hence, the use of such sluice valves for regulatory purpose (in fully closed or fully open position) on pipelines where the operating pressures are low, becomes expensive. Excepting at critical points such as the starting point of main pipe line and branches, the sluice valve has been replaced by fabricated MS Tee valves which are simple to manufacture and cost about one third of the cost of the sluice valve.

Table - 2
Allowable Heads for Plain PVC & PVC Ribloc[R] Pipes

Sl. No.	Class/Diameter	Allowable Head	Remarks
1.	PVC 2.5 kg/cm^2	20 m	5m reduction for temperature and water hammer
2.	PVC 4.0 kg/cm^2	35 m	- do -
3.	PVC Ribloc[R]		Reduction for temperature & water hammer to be made in the rated pressure.
	i. Profile 85-09 250 mm	9.3 m	
	ii. Profile 90-09 300 mm 350 mm 400 mm	11.3 m 9.7 m 8.5 m	
	iii. Profile 400 mm 500 mm 600 mm	110-09 11.0 m 8.8 m 7.4 m	
	iv. Profile 125-09 400 mm 450 mm 500 mm 600 mm 750 mm	12.0 m 10.7 m 9.6 m 8.0 m 6.4 m	

3.7 INSTALLATION REQUIREMENTS.

The pipeline should be allowed to come to within a few degrees of the temperature that it will have after complete covering prior to any backfilling beyond shading. The pipeline should be installed at sufficient depth below the ground surface to provide protection from hazards imposed by temperatures, or soil cracking. The minimum depth of cover should be as follows -

(i) 450 mm for pipes 25 to 60 mm diameter

(ii) 600 mm. for pipes 75 to 100 mm diameter

(iii) 760 mm. for pipes 125 mm or more in diameter.

Thrust block - Thrust block should be provided as per requirement.

3.8 REQUIREMENT FOR SYSTEM FUNCTIONING.

3.8.1 Water is let out in the pipeline from source (Reservoir) either by gravity or by pumping and it is seen that sufficient working head is available at every transit working point.

3.8.2 Arrangement for measuring the discharge while letting out the water in the pipeline must be available e.g.'v' notch, partial flume, ventury flume, W.S.R. etc. Water flows through main pipeline on the basis of hydraulic gradient available at various points. At low level the available hydraulic gradient is more resulting in higher discharges. To control and monitor discharges accurately, sufficient valves may be provided.

3.8.3 At junction of branching of pipe line, diversion of desired discharge is the basic requirement. It can be achieved by providing adequate control by limiting sizes of pipes or by control devices.

For continuity of uniform flow and for better operation, introduction of the air relief valves, expansion joints, pressure release valve, thrust blocks, check valves and sluice valves are useful.

3.8.4 Through branches water is supplied to various laterals. The hydrants are installed on lateral to facilitate irrigation of the command. It is desirable to provide separate hydrant for individual holding or farmer, however in Konkan area because of the small land holdings, one hydrant is provided for 1 ha. In order to achieve equity in distribution,proper clubbing and scheduling of group of hydrants is necessary. For controlling hydraulic gradient at every hydrant point, the float valve may be provided but providing such valve at every hydrant point is very costly affair. Hence disciplined scheduling and distribution of water will be economical and practicable. Providing drains at tail end of the lateral is necessary. In case of emergency repairs, arrangements should be provided to empty the part of the system.

3.8.5 At every hydrant point, portable gauge to measure the hydraulic gradient is one of the important requirements. Measurement of discharge through every hydrant will help in effective implementation of irrigation scheduling.

3.9 SYSTEM COMPONENTS AND SYSTEM LAYOUT

Various types of structures used in a concrete pipe line system are described below.

3.9.1 Stands

These structures are generally constructed from vertical sections of pipe. They may serve as pump stand, overflow stand and float valve stand. In addition they may also function as vents and sand traps. Sometimes, when gates are not required in the stands, they may be capped with a smaller vent above the hydraulic grade line. Float valve stands are used on steeper slopes where the rate of supply can be varied and automatic control offers advantages. Stands should be of proper height. Stands higher than necessary may complicate valve operation and may permit high heads of water to build up, leading to excessive line pressures. Stands should be placed at each inlet to a concrete irrigation pipe system and at such points as required. They should be designed to avoid entrainment of air, to allow 0.30 to 1.52 meters of free board, and to withstand the pressure within the structure. The downward water velocities should not exceed 0.60 meter per sec. In any case such velocity should not exceed the average pipe line velocity.

3.9.2 Pump Stands

Pump stands are used to convey the flow of the pump into the concrete pipe system, and also to serve the functions of other stands as well. The minimum dimensions of pump stands (fig. 1 & 2) should be determined by maximum downwards velocity of 0.60 meter per sec. It is desirable to have the diemeter large enough to allow access for repairs. A pump stand should not be capped where the well has a tendency to pump sand.

3.9.3 Overflow Stand

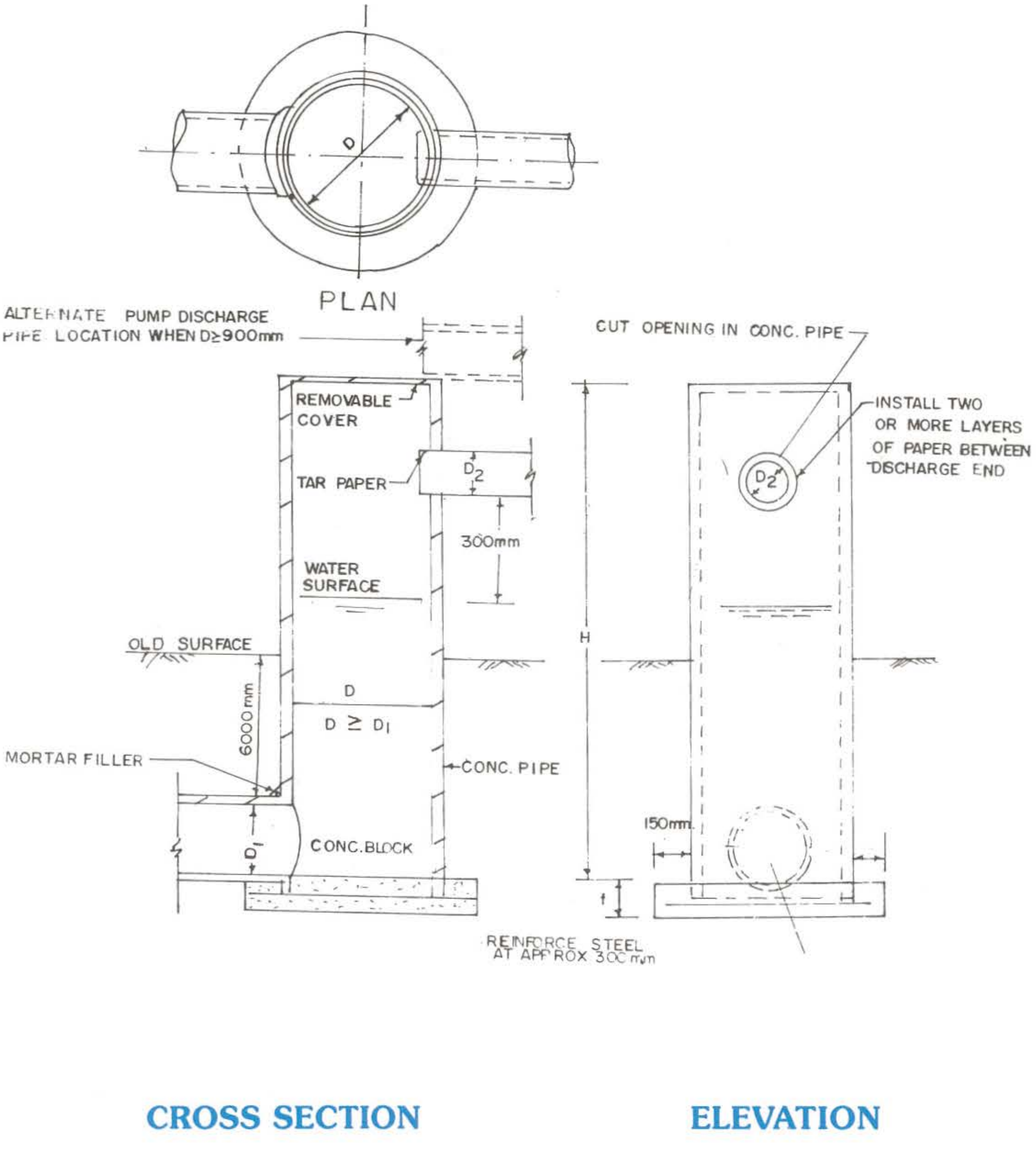
Overflow stands (Fig. 3 & 6) function both as check and drop structures in addition to the usual function of a stand. As checks, they regulate pressure to maintain constant upstream flow from hydrants or into laterals. As drop structures, they cause a drop in the hydraulic gradient, thus limiting pipe line pressure. This structure is not required on a flat area or on areas with very slight slopes. Overflow stands are generally two concrete pipe stands joined together with connections between them at the pipe line elevations, where the gate valve is installed and at the elevation of the overlap. The upstream stand is essentially a gate stand. The downstream stand is of the same diameter as the pipe line.

3.9.4 Sand Traps

Sand Traps (Fig. 4) permit the settling out of sand and other suspended material in the water. These are useful where the water is delivered into the system by a pump. They must have sufficient cross section to ensure low velocities. Table-3 gives the 'Recommended Diameters' of sand traps.

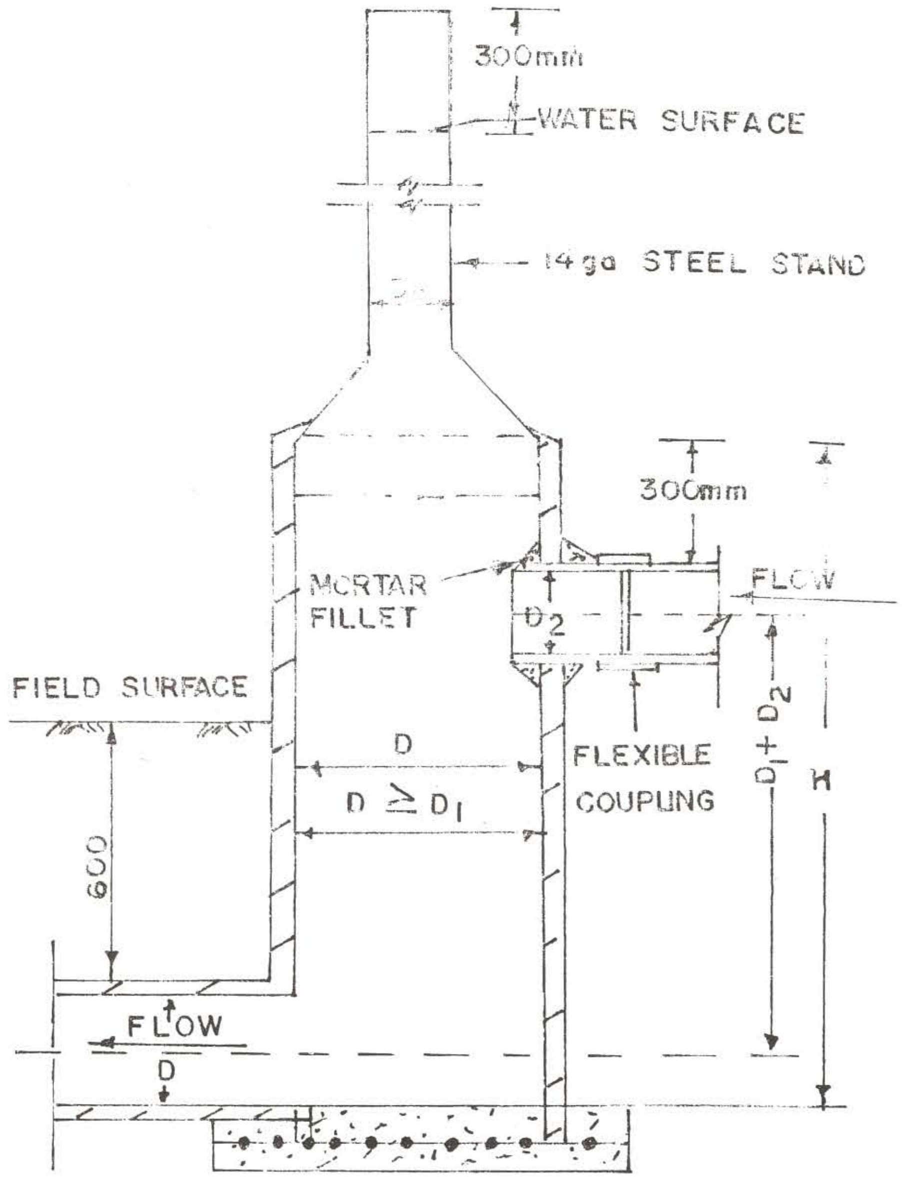
Table - 3
Recommended Diameter for Sand Traps

Maximum Flow (lit/sec.)	Diameter (mm)
35	750
40	800
50	900
70	900
90	1000
110	1200
140	1500



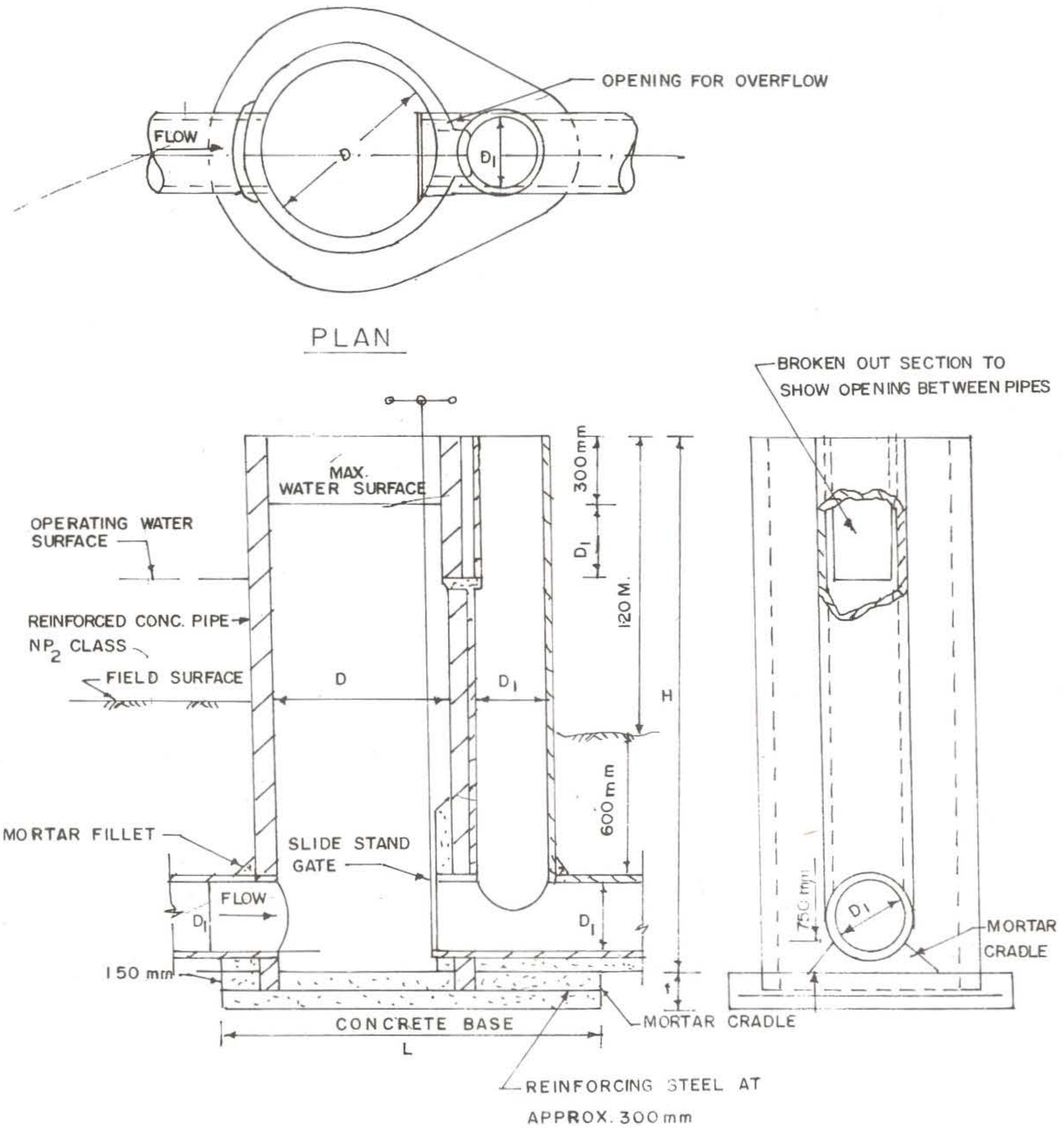
CROSS SECTION **ELEVATION**

Fig. 1 : Low Head Pump Stand (Source US SCS, 1967)



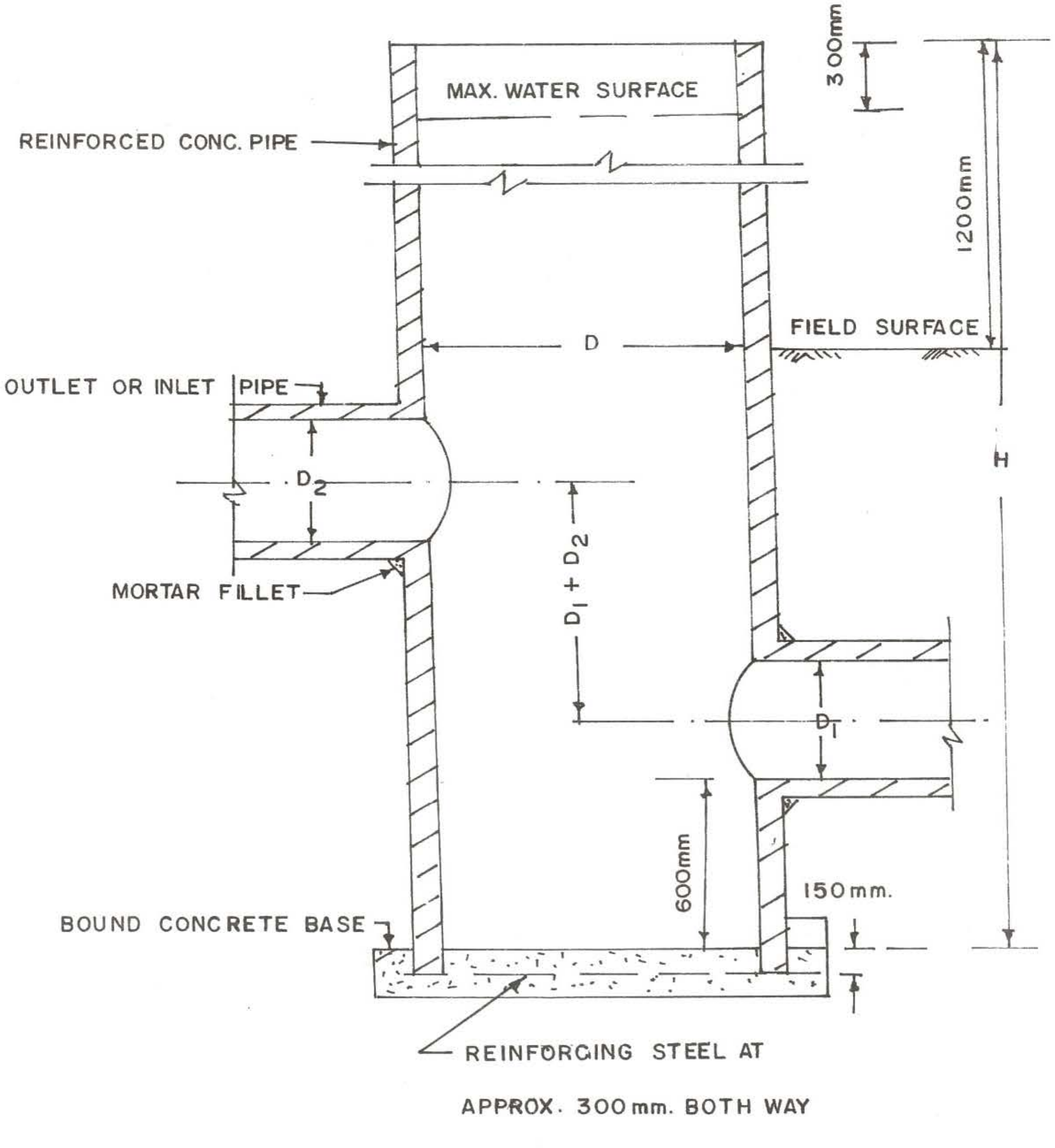
CROSS SECTION

Fig. 2 : High Head Tapered Pump Stand (Source US SCS, 1967)



CROSS SECTION **ELEVATION**

Fig. 3 : Overflow Gate Stand (Source US SCS, 1967)



CROSS SECTION

Fig. 4 : Stand Trap (Source US SCS, 1967)

3.9.5 Gate Stands

Gate stands (Fig.5) prevent high pressure, act as air vents and surge chambers, and control the flow by means of one or more gate valves. They may also serve as stands for pumps to discharge into, and/or as sand traps. It is used to regulate the flow into laterals, or where, on a single line, it is desirable to create upstream pressure so that water will flow from hydrants at that point. They should be of such dimensions that gates are accessible for repair.

3.9.6 Float Valve

Float valve stands (Fig. 7 & 8) are used in series on steep slopes to form a semi-closed pressure in the reach of pipe immediately from it, and such valves release into the stand only as much water as hydrants further downstream are able to take. Thus, by opening and closing, the valve maintains a nearly constant water level in the stand, which is connected directly to the line or lines downstream through which the water flows. The downstream pressure is determined by water surface elevation, and hence by the setting of the float.

When float valves are designed to prevent almost all fluctuations in the water surface elevation, there is tendency for the valve to 'hunt' - a partial opening and closing occurs that produces a rhythmic variation in flow. This tendency is amplified when float valves are in series. Hunting is prevented by providing water surface elevation fluctuation in the stand, between valve-open and valve-closed position, of 150mm to 300 mm, and by other adjustments to the float. Thus, the float should be tall relative to its diameter or there should be linkage between valve and float. Float stands should be installed at intervals of about 3.0 m of drop in the line. They eliminate the need for many high overflow stands. These stands should be a minimum of 750 mm in dia and should have about 600 mm of free board. The size of float valve required depends upon the head loss available and the friction loss in the valve when wide open under flow. Table 4 gives the head loss under various conditions of flow and sizes of valve.

Table - 4
Rates of Flow l/s Through Wide-open Float Valves with Head losses.

	Head Loss in Meters of Water				
Size\Rate of (mm) \flow in l/s	5.0	10.0	20.0	40.0	80.0
100	9	15	18	28	48
125	15	20	28	45	60
200	36	50	70	110	160

3.9.7 Gravity Inlets

For pipe lines into which water flows by gravity from an open channel/ Water course, a gravity inlet structure (Fig. 9 to 13) that may include a sand trap, debris screen, etc. is needed to develop full pipe flow and keep trash out.

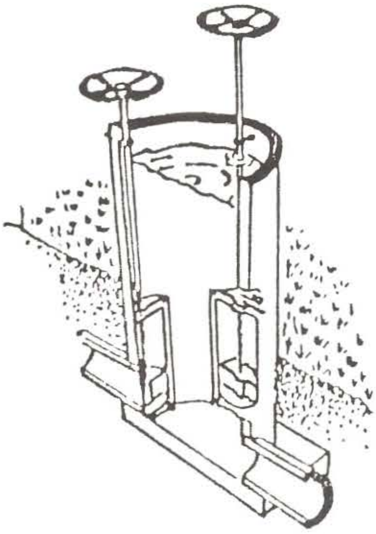


Fig. 5 : Section of a gate stand

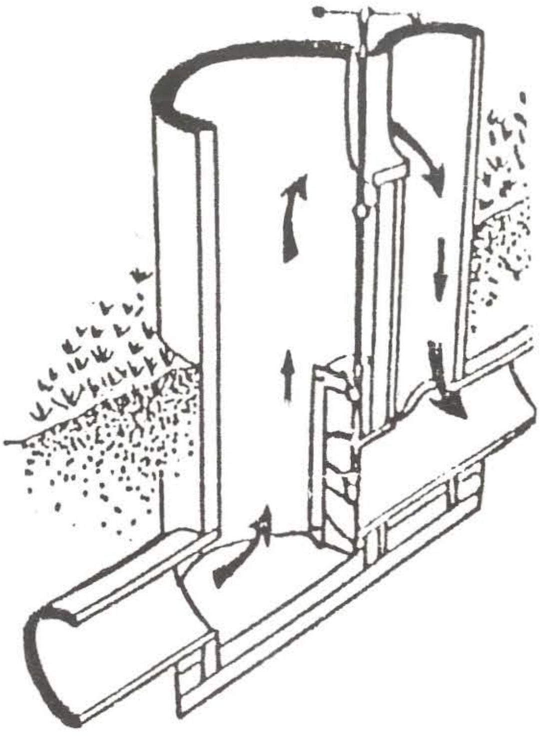
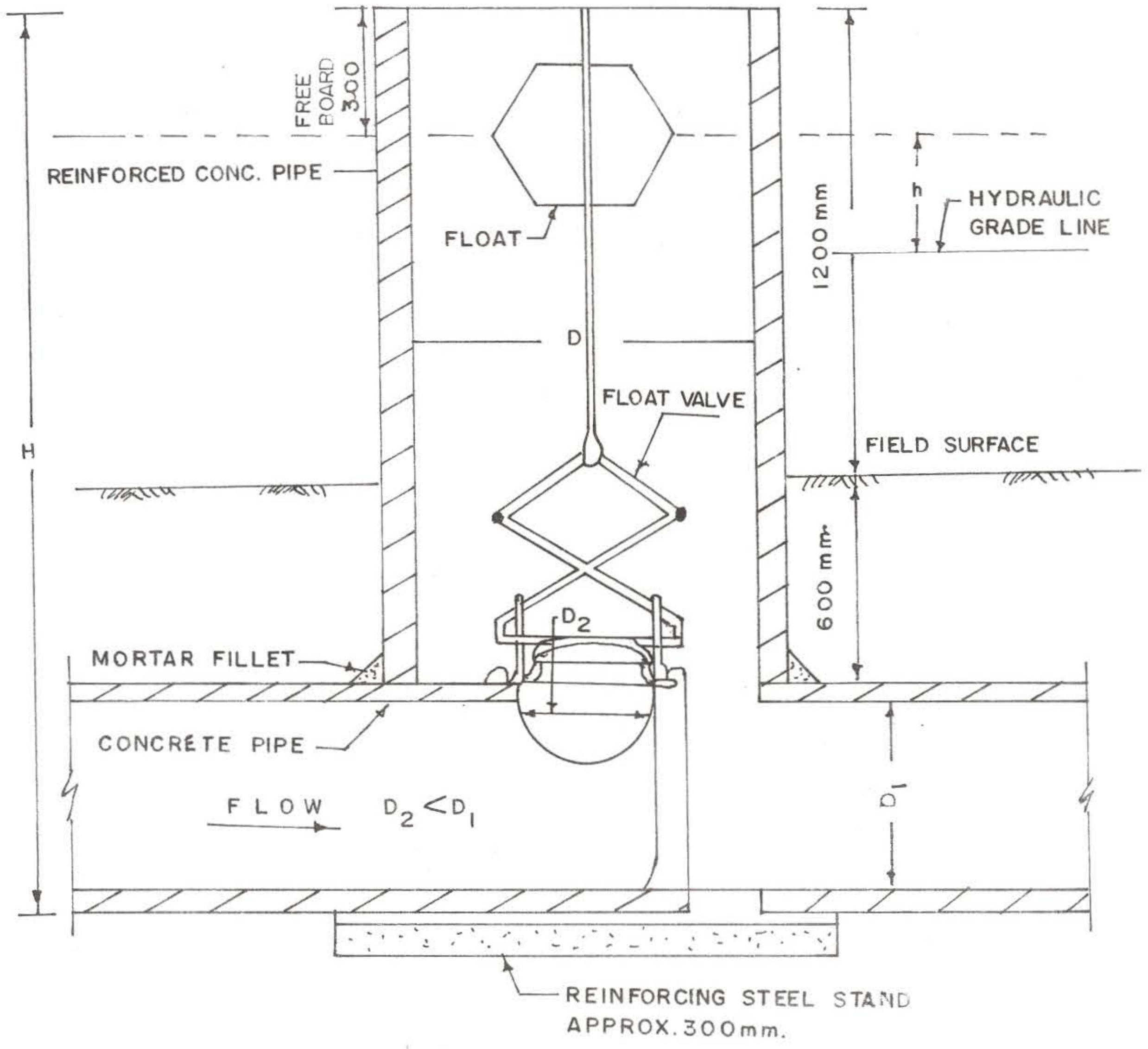


Fig. 6 : Section of an overflow stand.



CROSS SECTION

Fig. 7 : Float Valve Stand (Source US SCS, 1967)

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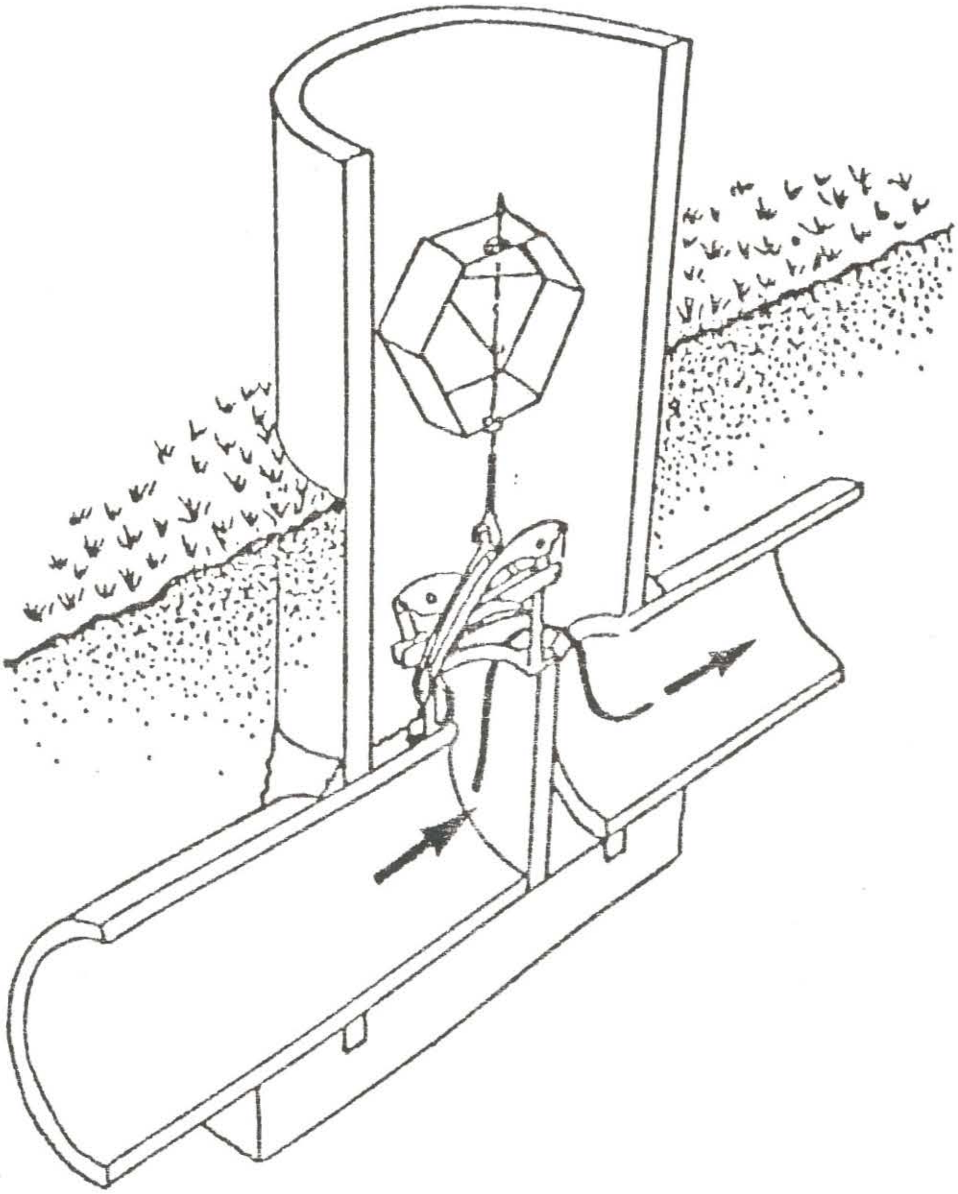
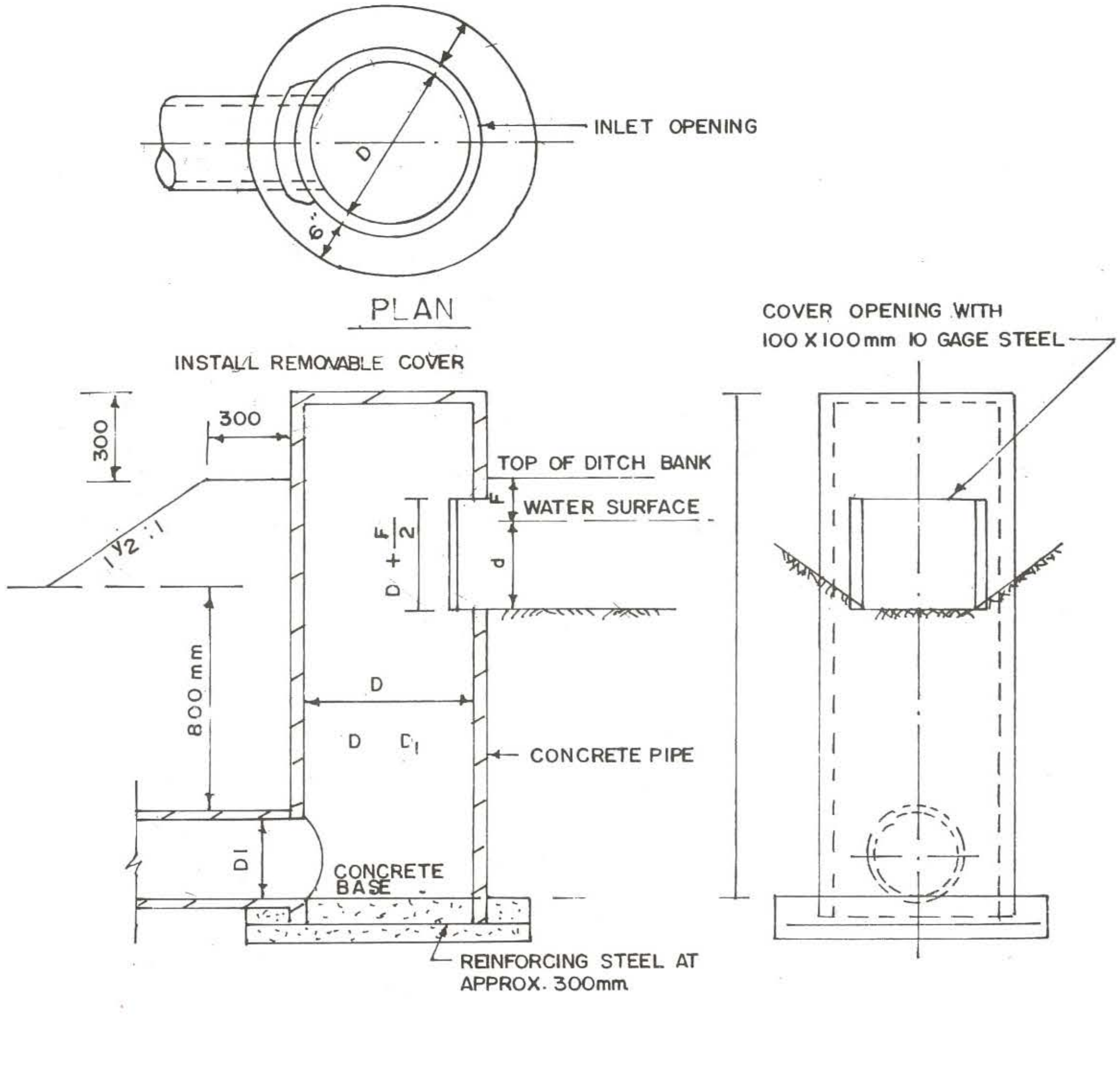
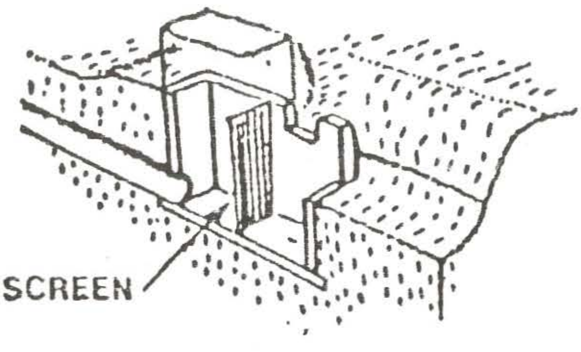


Fig. 8 : Section of a float-valve stand (Source - US SCS, 1967)

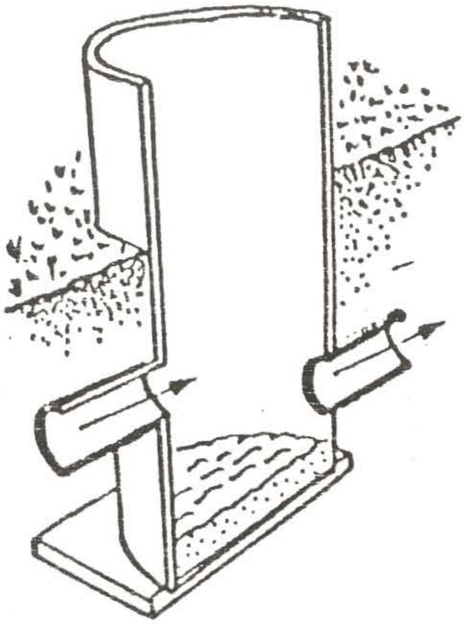


CROSS SECTION **ELEVATION**

Fig. 9 : Gravity inlet (Source - US SCS, 1967)



Gravity inlet for buried pipe



A concrete pipe sand trap

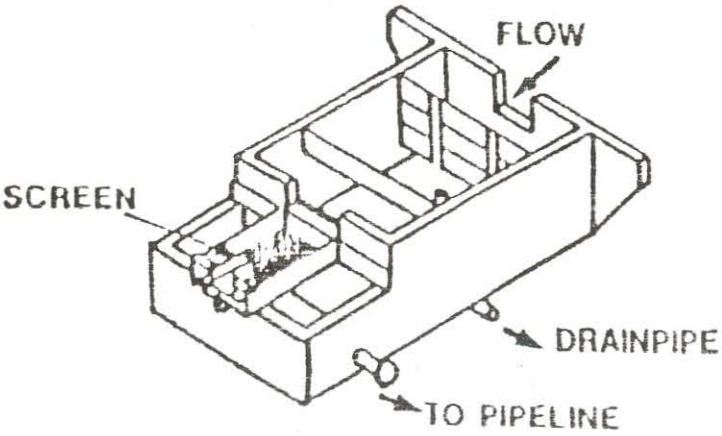


Fig. 10 : Typical trash screen

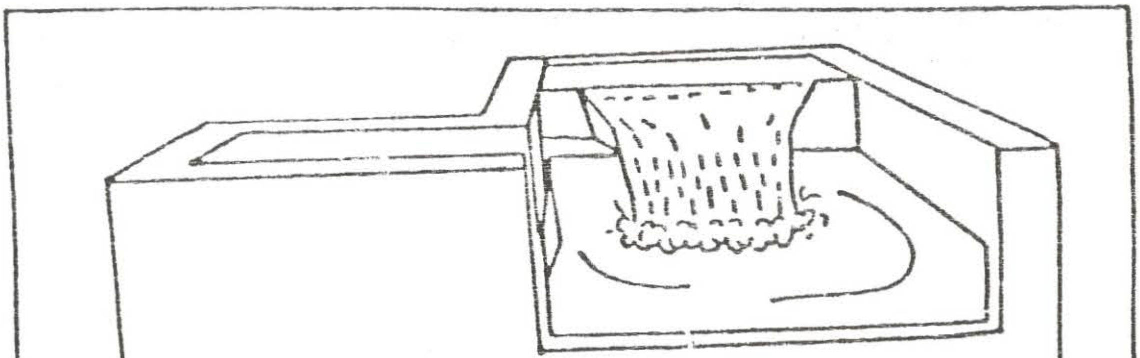
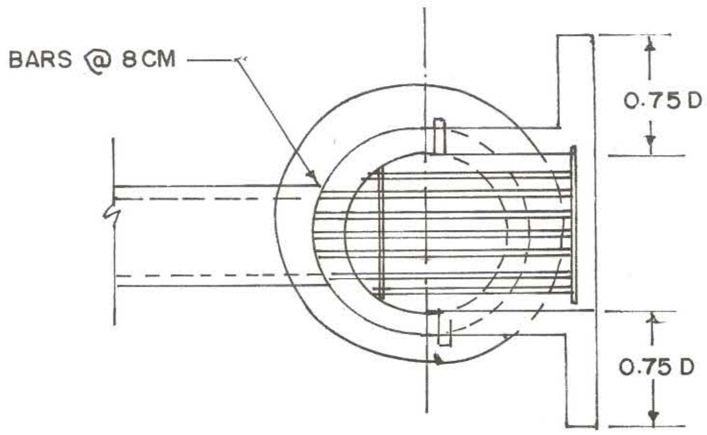
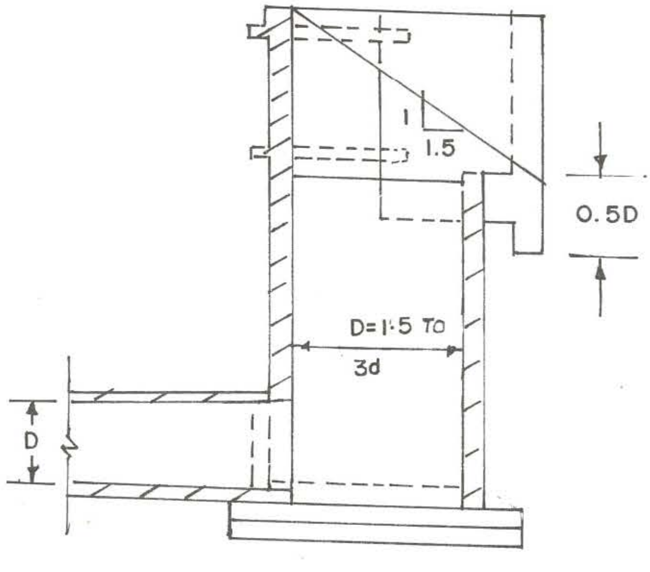


Fig. 11 : Desilting box and trash screen (Source - US SCS, 1967)



PLAN



SECTION

Fig. 12 : Pipeline inlet with trash gate (Source - US SCS, 1976)

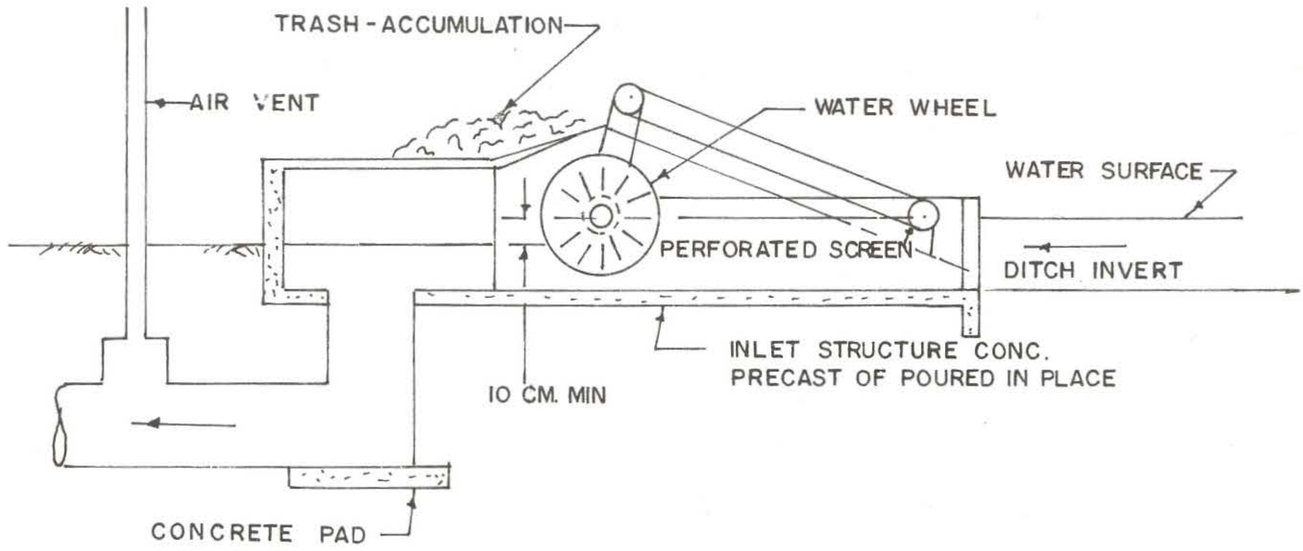


Fig. 13 : LONGITUDINAL SECTION
Pipeline inlet with water-powered trash screen.
Similar units are available with electric drive motor.
(Source - Tensen, 1983)

3.9.8 Vent Stand

These are used to relieve pressure, release air and prevent vaccum. Vents should be located at the following points:

i) at the downstream end of each lateral.

ii) at the design point downstream from any pump stand where the design velocity exceeds 0.30 m/s

iii) at points where there are changes in grade in down-ward direction of flow of more than ten degrees.

iv) at summits in the pipeline, and

v) immediately upstream from line gates where closure of the gate would make this the downstream end of a lateral or line.

The design point in (ii) above is determined by the equation L = 5.9 VD, where L is the distance downstream in meters from the air entraining stand, V is the maximum design velocity in meters per second, and D is the inside diameter of the pipe in meters. The maximum height of the vent above the center line of the pipeline must not exceed the safe working head of the pipeline.

3.10 VALVES AND OUTLETS

3.10.1 Drain Valves

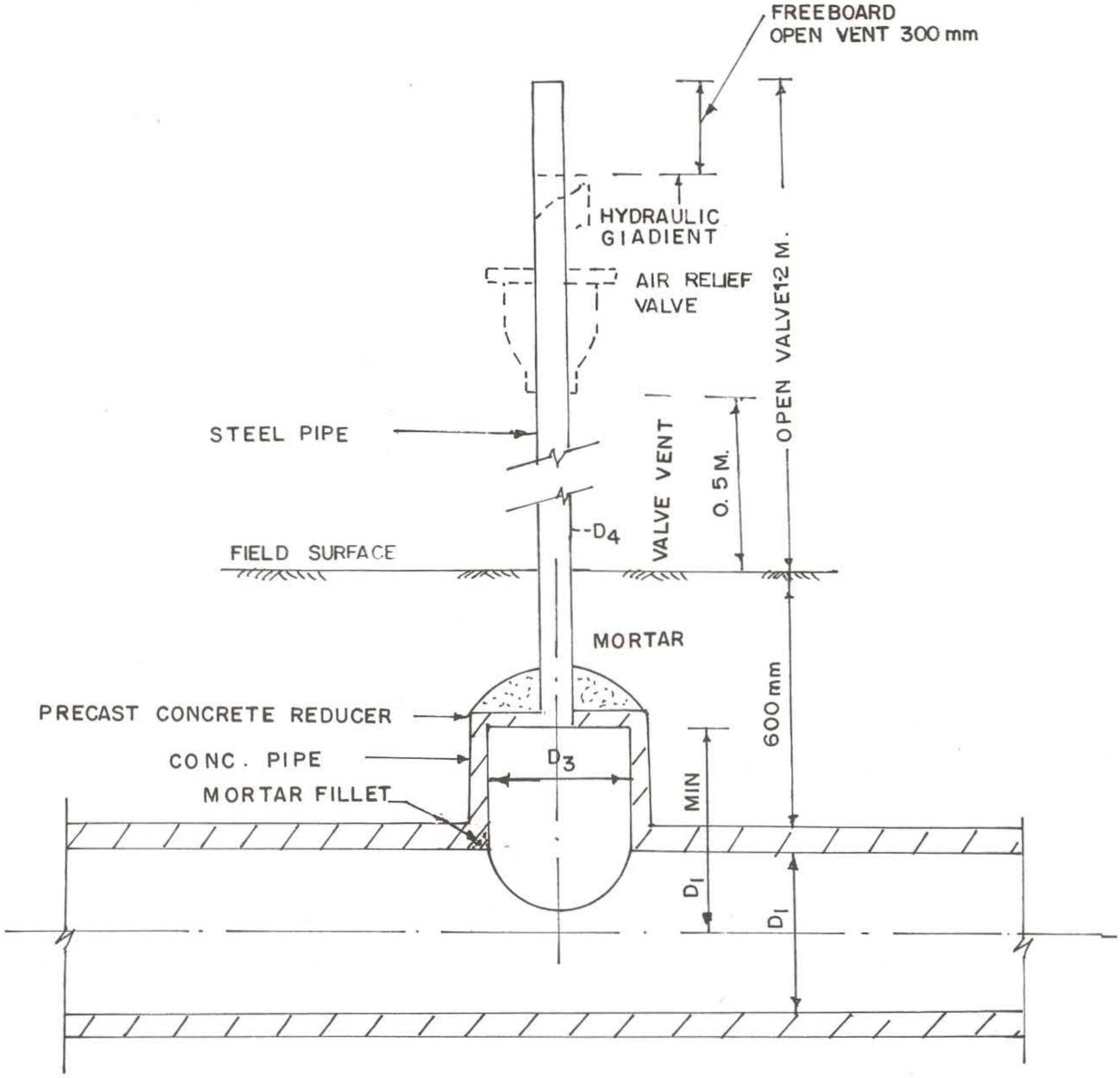
These may be provided at low points in lines and at other points as necessary.

3.10.2 Outlets

Some type of outlet structure or hydrant is necessary in pipelines to deliver water to the land or into some distributing device. Hydrants are risers built from vertical sections of pipe which are saddled over openings in the pipe line and permanently attached to it. Some kind of valve or gate is installed in the riser to regulate discharge through the hydrant. These valves are described below:

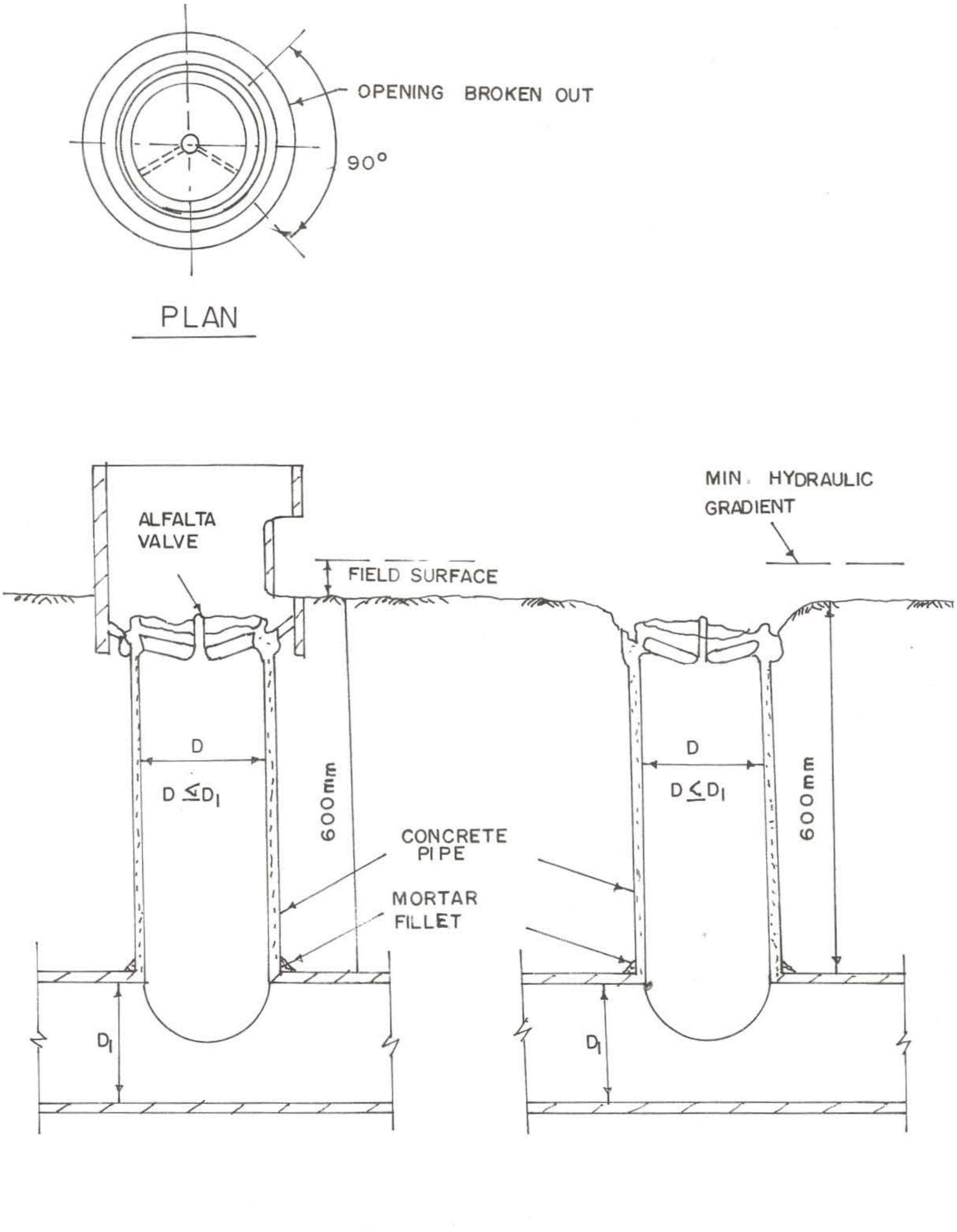
(i) Alfalfa Valve :

An alfalfa valve (Fig. 15, 16 & 17) is a screw valve grouted to the top of a pipe riser. A handle and cap plate are attached to a threaded rod that moves up or down as the handle is turned. When the valve is closed, the cap plate fits the circular edge of the valve case to make it watertight. When the plate is lifted by turning the handle, water is released from all sides of the valve. These valves are used to distribute water directly border strips and basins. The top should be set 75 to 100 mm below the ground surface to minimize interference with farming operations and to reduce erosion from the irrigation stream. Alfalfa valves can be fitted with portable hydrants to connect to the surface. Table 5 gives the maximum 'Design Capacities Recommended for Alfalfa Valves'.



CROSS SECTION

Fig. 14 : Air Vent (Source - US SCS, 1978)



CROSS SECTION **CROSS SECTION**

Fig. 15 - Alfalfa Valve

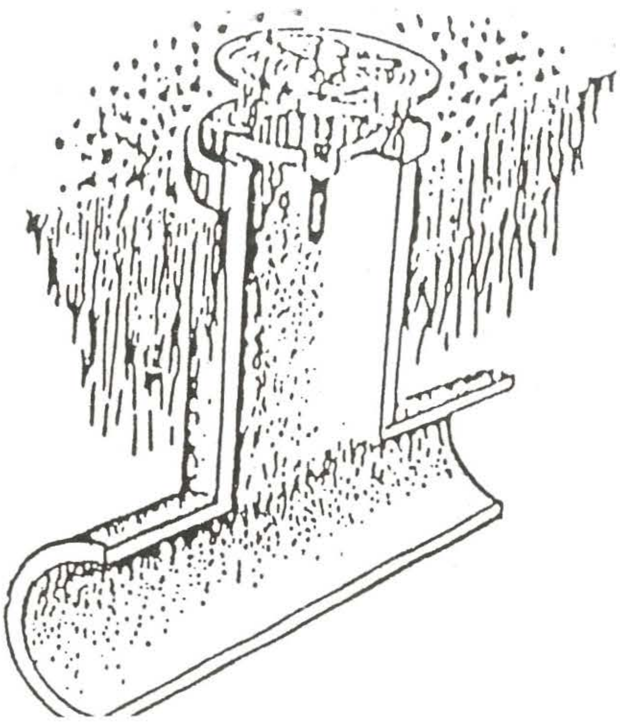


Fig. 16 : Section of an alfalfa valve mounted on a pipe.

Table - 5
Alfalfa Valves - Maximum Design Capacities

Inside Dia of Riser(mm)	Dia of port (mm)	Maximum DesignCapacities(l/sec)	
		Low Head (1)	High Head (2)
150	150	22.6	45.3
200	200	39.6	79.3
250	250	62.3	124.5
300	304	87.7	178.3
350	350	121.7	243.4
400	400	158.5	316.9
450	450	200.9	401.9
500	500	246.2	495.2

(ii) Orchard Valves (Fig. 18)

These are similar to alfalfa valves but have a smaller flow capacity and are so designed that they can be placed at the top of the riser. Table 6 gives 'Size and Recommended Maximum Capacities for Orchard Valves'.

Table - 6
Orchard Valves - Size Recommended Maximum Capacities

Inside Dia of Riser(mm)	Inside Dia of Port(mm)	Dia of Valve out(mm)	Approx.DesignCapacities(l/s)	
			Low Head (1)	High Head (2)
150	150/200	40	1.1	2.2
150	150/200	60	3.4	6.5
150	200	90	6.5	12.7
150	250	150	18.9	37.9
200	200/250	125	13.0	26.3
200	300	200	33.4	67.0
250	250/300	150	18.9	37.0
250	300	150	22.0	44.4
250	350	250	52.3	105.0
300	300/350	200	33.4	67.1
300	400	300	75.5	151.4

(iii) Open pot outlets :

In open pot outlets (Fig. 19 & 20) the riser extends far enough above the ground surface for two or more slide-gates tubes to be installed. An orchard valve is placed below the slide gate. This kind of outlet distributes water through the gates to furrows and is used principally in orchard irrigation systems. If line pressure is low enough that pot will not over flow, orchard valve is not needed in the riser. Table 7 gives 'Maximum Design Capacities Recommended with Orchard Valves.' Table 8 gives pot sizes for various sizes and numbers of slide gates.

Table - 7
Open Pot Outlets with Orchard Valves Design Capacities

Maximum Recommended Capacities				
for Slide Gates		for Orchard Valves		
Dia of Opening (mm)	Max Capacity (l/s)	Inside Dia of Riser(mm)	Dia of Valves (mm)	Design Capacity (l/s)
25	0.6	150	40	1.1
40	1.1	150	60	3.4
50	1.1	150	90	6.5
75	0.4	200	125	13.10
100	7.4	250	150	15.10
125	11.6	250	160	22.20
150	17.0	300	200	33.30

Table - 8
Pot Sizes Recommended for Various Sizes and Number of Slide Gates.

Dia of Opening(mm)	Number of Gates with Size
150	Two gates up to 75 mm diameter.
200	Four gates up to 25 mm diameter. Two gates up to 125 mm diameter.
250	Four gates up to 50 mm diameter. Two gates up to 150 mm diameter.
300	Six gates up to 25 mm diameter. Four gates up to 50 mm diameter.
350	Six gates up to 40 mm diameter. Four gates up to 75 mm diameter.
400	Eight gates up to 25 mm diameter. Four gates up to 100 mm diameter.

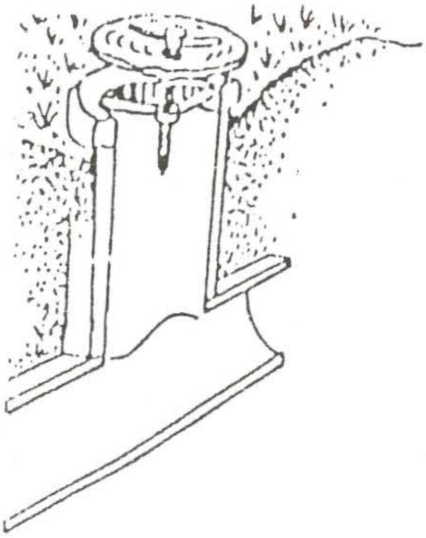


Fig. 17 :
Section of an alfalfa valve

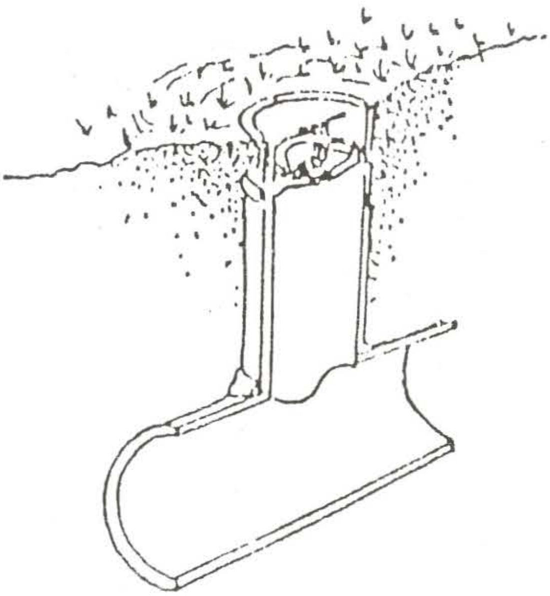


Fig. 18 :
Orchard valve

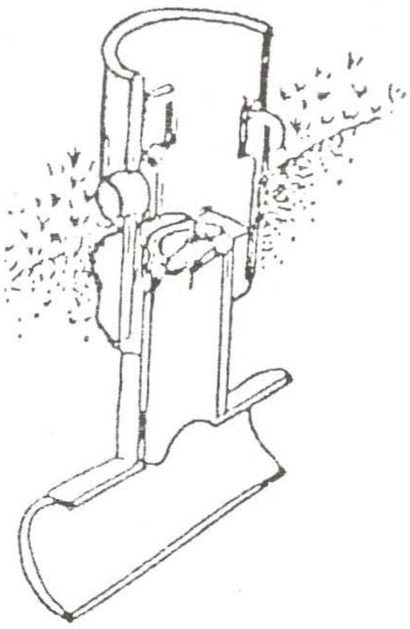


Fig. 19 :
Open-pot outlet with an orchard valve and slide-gate control

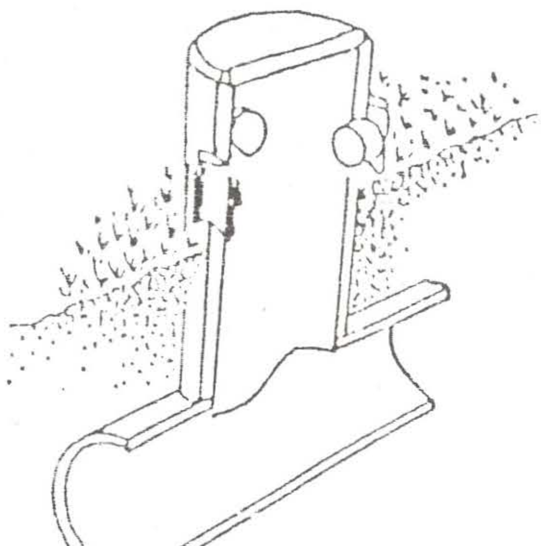


Fig. 20 :
Section of air capped riser or pot outlet

(iv) Capped risers or pot outlets :

In these outlets, the top is closed and the slide gates are installed on the outside of the riser, orchard valve is not used. The main advantage for capped pot outlets is that leaves cannot fall into the pot and clog the slide gates and that an orchard valve is not needed. These can be more than 0.60 m above the ground. Table 9 gives "Maximum Design Capacity Recommended for Slide Gates for Capped Risers."

Table - 9
Maximum Design Capacities Recommended for Slide Gates for Capped Risers.

Dia of Opening (mm)	Maximum Design Capacity (l/s)
25	0.56
40	1.10
50	2.0
75	4.2
100	7.4
125	11.6
150	17.0

4.2.1 Steps to be followed in Planning and Designing of PVC Pipeline System

1) Decide the chak size below an outlet. The chak size should be so selected that it should be between 5 to 12 ha. Mark the boundries of a chak.

2) Mark the alignment of PVC pipeline. The alignment of PVC pipeline should be so decided that it generally passes through the centre of chak area.

3) Fix the positions of Tee/Chambers on main line and branches of PVC Line. Generally, the Tee is provided for an area of about one Ha. The position of chamber is so selected that the complete area can be irrigated without any hindrance.

4) Prepare the rotational water supply scheduling considering two or three chambers run at a time and period of irrigation is 6 days in a week. From this, decide the discharge that a particular reach has to carry taking into consideration that each chamber will discharge a flow of 10 to 15 lit/sec. The rate of discharge can be varied by considering infiltration rate of soil and slope of ground profile.

5) Knowing the discharge through a particular reach, find out the frictional losses in that reach by using the nomogram received from manufacturers. To account for the losses due to Tees, bends etc. equivalent length of 10 m of pipe is considered.

   As far as possible, the discharge in the line should be modular during all the rotations. This can be adjusted by fixing the seasonal 'ON-OFF' schedule as per the water availability and the crop water requirement. With modular discharge, the design and the operations can be made much simpler.

6) The hydraulic gradient line (HGL) at start of PVC line is taken as sill level of outlet as mentioned above. Thus knowing the H.G.L. at the end of particular reach is worked out by deducting the frictional losses through that reach.

7) Diameter of pipe is so decided that the effective head i.e. (HGL-GL) should not be less than 0.60 m. However, in exceptional cases effective head to the extent of 0.30 m may be allowed.

4.2.2 For laying pipe line distribution system, the plane table survey should be carried out. Before that village maps should be collected, property records of individual farmers shall be verified and checked from the revenue records. Total command shall be checked on the basis of revenue land records.

The information regarding existing (prevailing at the time of survey) cropping pattern should be collected from revenue record. For future crop pattern,the Agriculture Department should be consulted.

Data of strata classification for estimation of earthwork for pipeline laying should be collected.

Relevant climatological data for working out the crop water requirement should be collected.

A market survey for availability of various sizes of pipes alongwith product price should be conducted.

Block contour plan having contour interval 0.3 m may be prepared for full command to be covered by pipe distribution system.

To check the adoptability of pipeline distribution system by beneficiaries, a socio-economic survey of the area should be carried out.

4.3 MAPPING AND DRAWING

4.3.1 For grass root planning/initial planning, topographical map of the area is required. Contours, allied details shall be shown/drawn to have the idea of existing topography. Scale of map should be sufficiently large to facilitate reading of details even when the scale is reduced in one direction. Maps should depict all major details i.e. buildings, roads, railroads, lakes, ponds, irrigation structures etc.

4.3.2 The flow diagrams should be prepared for pipe line system. Any existing underground structures shall also be taken into account. The flow diagram and alignment shall be prepared.

4.3.3 Drawings

The following checklist applies to prepare drawings for underground pressure piping systems -

1) Prepare drawing register and line list.

2) Show underground foundations, conduit banks, cable, structures, and existing piping systems.

3) Show line size, line number and underground piping specifications for each line.

4) List all standards and specifications (with issue dates) used on project in reference drawing column.

5) Indicate standard number, run and outlet size or complete specifications for wet or dry tap.

6) Indicate length of piping requiring joint restraint.

7) Completely describe branch outlets, origin connections.
8) List above grade, concrete and other pertinent reference drawings.

9) Materials for special designs must be compatible with specifications.

10) Show centre lines and dimensions to points easily located by the field.

11) Give sufficient description, profiles, sections, elevations, or details for purchase and installation.

12) If the piping specification covers it, do not repeat on the drawing.

13) Eliminate unnecessary fittings e.g. attempt to relocate above grade piping.

14) Dimensions underground valves with extension stems from centre line of valve to top of hand wheel.

15) Indicate grade, elevation of floor, and pad elevations on each drawing.

16) Give complete purchase descriptions for all special valves or assign item numbers.

17) Check loading on all piping with less than 3 feet (1 m) or more than 8 feet (2.5 m) of cover.

18) Specify types of bedding.

19) Specify types of backfill.

20) Prepare test schedule-additional line numbers may be required for indentifying systems.

21) Indicate location of sidewalks and other above grade paving.

22) Add second number accounts properly described for field accounting e.g. firewater, cooling water, forced sewers etc.

23) Show location and size of culverts, ditches and open channels.

24) Show roads and crane accessways.

25) Design supports for valves and hydrants.

4.3.4 Use of Casing

Buried gravity and pressure piping systems can be installed under railroads, plant roads and equipment accessways without the use of casings, sleeves, or boots. Usually 1m (3 ft) of well compacted earth cover above the top of the pipe is sufficient to protect the pipe from most anticipated live and dead loads. Reinforced concrete paving and crane turning pads over these lines and further protection, if necessary where unstable soil or poor drainage exists.

Certain isolated conditions may dictate the use of casings, e.g. roads and highways outside industrial plant limits, railroads not owned by Industries and construction problems that would preclude maintaining of fire lanes or other safety requirements.

Casings are usually jacked, augered, or tunneled under roads, railroads, or accessways. Casing materials include carbon steel pipe, corrugated steel pipe (round, arch, or split) and reinforced concrete sewer and drain pipe. Considering corrosion resistance and strength, concrete pipe casings are probably the best choice.

Properly installed casings usually require all the following :

a) Casing pipe

b) Vents with bird screens on each end of the casing

c) Watertight end seals.

4.3.5 General Guidelines

While preparing underground construction drawings the following general guidelines may also be kept in mind in addition as mentioned in para 4.3.3.

1) Do not attempt to show everything on the plan drawing. Sections, elevations, details and profile drawings should be prepared as required.

2) Eliminate buried flanges and threaded connections where possible.

3) Keep copper and other metal pipe separated by a minimum of 450 mm to prevent corrosion.

4) Maintain potable water lines at a higher elevation than sewers.

5) Space piping so as to eliminate heat transfer.

6) Do not specify or design casings unless regulations dictate.

7) Trenches, valve pits, and orifice pits should be eliminated where possible.

8) Keep number of fittings as minimum as possible (bending is preferred to a fitting) to reduce pressure loss.

9) Do not locate manholes in roadways or underpipe racks.

10) Provide a uniform method of indicating slope of gravity piping i.e. percent slope. Percent slope is probably the most common specification i.e. 1.0/100 m, 0.01/m, etc. all are 1 percent slope.

11) Locate catch basins near the corner of curbed area - not in the centre.

12) Indicate insulating flange gasket sets on underground piping drawings only. can be placed on the bench.

13) Do not locate catch basins or open hubs under equipment.

4.4 SOIL DATA

4.4.1 Information regarding existing soil and its characteristic is essential. This information includes, types of soils (clay, silt, loam, S.R., H.R.), chemical and physical properties of soil. The depth of pipe and cover over top of pipe are determined by soil load. The cost of pipe line can be influenced by existing high groundwater table.

4.4.2 Soil PH can also affect the choice of material of pipe. PH < 5 would preclude use of iron and concrete pipe.

4.4.3 The basic data related to nature and extent of existing soil should be obtained. The information such as Texture of soil, soil PH, existing groundwater table, soil specific characteristics, drainability, shear strength, compressibility, infilteration rate, soil classification etc. regarding existing strata should be collected.

4.5 WATER REQUIREMENT OF CROPS IN DIFFERENT SEASONS.

4.5.1 Both the design engineer and the farmer should know how much water will be required for production of crops to be grown under irrigation and how much and how often water must be applied. The engineer needs this information to determine the flow of water required at various points in the system. The farmer needs it, as a guide to apply the correct amount of water at the proper time. A system designed with inadequate capacity to meet the peak crop water demands will result in reduction of crop yields.

4.5.2 Total water requirements vary from place to place, and are dependent on the type of the crops grown, local climatic conditions, and the efficiency of application. Therefore, it is necessary to estimate the irrigation water requirement accurately for the project area by using modified penman method or any other suitable method, depending on the availability of climatic data. Leaching requirements should also be added, if there are salt problems.

4.5.3 The frequency and amount of irrigation water applied depend on type of crop, stage of growth, soil type and climatic conditions. Some crops, such as pasture require frequent application during the entire growing season. On the other hand, water should not be applied to crops such as cereals or legumes during ripening. Root characteristics of crops also are important factors in determining how often crops need irrigation. Shallow-rooted crops such as vegetables need frequent light applications to maintain moisture in the upper 0.50 m of soil. Deep rooted crops such as alfalfa, sugarcane and cotton require less frequent applications but need more water at each irrigation.

4.5.4 The water holding capacity of the soil is an important factor in determining the amount and frequency of application. Coarse textured soils have low moisture storage capacity. Clay soils have high moisture storage capacity. Therefore, smaller and more frequent application of water must be made to crops grown on coarse soils than on fine textured soils. If more water is applied than the soil can hold, waste will occur through runoff and deep percolation. Table-10 gives the average amount of water needed at each application for various soils and crop conditions for accurate determination of depth and frequency of irrigation application.

Table - 10
Recommended Amount of Water to Apply (in cm./m.)

Root Zone	Sandy Soil	Loamy Soil	Clay Soil
Shallow (less than 60cm)	2.5 to 5.0	5.0 to 7.5	7.5 to 10.0
Medium (60-90 cm)	5.0 to 7.5	10.0 to 15.0	15.0 to 20.0
Deep (120-180 cm)	10.0 to 15.0	20.0 to 25.0	25.0 to 27.5

Water requirement of crop implies the total amount of water, regardless of the source, required by crop in a given period of time for its normal growth. It thus, includes water needed to meet the losses through evapo-transpiration, application losses and special needs.

4.6 DESIGN SPECIFICATIONS

4.6.1 Working Pressure

(a) **High Pressure Pipeline :** The pipeline shall have a pressure class rating greater than the State of Working pressure plus surge at any point.

If the surge is not known, the working pressure shall not be exceed maximum allowable working pressure as given in Table No.11 for the particular pipe and SDR used. Water hammer considerations and procedures for calculating surge pressure for PVC pipe line for irrigation system are given by Script WR (1974).

TABLE - 11
Pressure Rating Service Factors for Temperature from 23° to 60°C (73.4 to 140°F) for PVC and PE Pipes

Temperature Deg. C	Deg.F	PVC Factor	PE Factor
23	73.4	1.00	1.00
26.7	80	0.88	0.93
32.2	90	0.75	0.81
37.8	100	0.62	0.70
43.3	110	0.50	
48.9	120	0.40	
54.4	130	0.30	
60.0	140	0.22	

(b) **Low Head Pipe lines :** Pipelines using low head pipe shall be designed such that the maximum static or working pressure of the system, including free board, does not exceed 15.2 m (50 ft) of water.

4.6.2 Service Factor

All pressure ratings are determined in a water environment of 23 +/-2 deg C (73.4 +/-3.6 deg F). As the temperature of the environment or fluid increases, the pipe becomes more ductile. Because of this effect, the pressure rating must be decreased for use at higher temperature to allow for safe operation of the pipe. The service factors for PVC and PE pipe are shown in Table 11. For ABS pipe, service factor recommended by the manufacturer should be used.

4.6.3 System Capacity

The design capacity of the pipe line shall be sufficient to provide an adequate flow of water for all methods of irrigation planned.

4.6.4 Friction Losses

For design purposes, friction head losses shall not be less than those computed by the Hazen-Williams equation using a flow coefficient 'C' for the pipe which differs with pipe material, rate of flow etc. As the computer facilities are available these can be more conveniently used. However value of 'C' equal to '150' is normally adopted.

4.6.5 Flow Velocity

The pipe system is liable to clogging/choking due to the sedimentation. Hence minimum permissible velocity should be fixed to safeguard the system against silting.

The design water velocity in a pipe line when operating at system capacity, should not exceed 1.52 m/(5 ft/sec). Special consideration must be given to assure that proper pressure and/or air relief valves are used with all velocities.

4.6.6 Outlets

Outlet shall have adequate capacity at the pipe line working pressure to deliver the design flow to the distribution system at the design operating pressure of the respective system i.e. Sprinklers, surface, pipe, emitters, triclets, etc.

4.6.7 Check Valve

A check valve shall be installed between the pump discharge and the pipeline where deterimental back flow may occur. It shall be designed to close without slamming shut, at the point zero velocity before damaging reversal of flow can occur.

4.6.8 Pressure Relief Valves

These shall be installed between the pump discharge and the pipe line when excessive pressures can develope by operating with all valves closed. Pressure relief valves or surge chambers shall be installed on the discharge side of the check valve where back flow may occur and at the end of the pipe line when needed to relieve surge.

4.6.9 Low Head Systems

Pressure relief valves may be used as alternative to serve the pressure relief functions of vents and stands open to the atmosphere. They do not function as air release valves and should not be substituted for such valves where release of entrapped air is required.

Pressure release valves shall be large enough to pass the full pump discharge with a pipe line pressure not greater than 50% above the permissible working head of the pipe.

Pressure relief valves shall be marked with the pressure at which the valve starts to open. Adjustable valves shall be installed in such a manner to prevent changing of the adjustment marked on the valves.

4.6.10 High Pressure Systems

Pressure relief valves shall be large enough to pass the full pump discharge with a pipe line pressure no greater than 50% above the permissible working head of the pipe and shall be set to open at a pressure no greater than 0.345 kg/cm^2 (5 psi) above the pressure rating of the pipe.

4.6.11 Air Release and Vaccum Relief Valve

Air release and vaccum relief valves shall be installed at all summits, at the ends and the entrance of the pipelines to provide for air escape and air entrance. Combination of air/vaccum release valves which provide both functions may be used.

4.6.12 Air Flow Capacity

Valves having large orifices to exhaust large quantities to air from pipe lines when filling and to allow air to enter to prevent a vaccum when draining are required at the end and entrance of all pipe lines. Values intended to release entraped air only may have smaller orifices and are required at all summits.

LOW HEAD SYSTEMS (NOT OPEN TO ATMOSPHERE)

Air vaccum relief valves shall be provided at each of the locations of laterals and summits.

The size of valve outlet for low head system shall be specified as per the various sizes of pipes.

High pressure System : The ratio of air release valve diameter to pipe diameter shall not be less than 0.1.

4.7 PIPE HYDRAULICS AND DESIGN FORMULAE

The design of supply conduits is dependent on resistance to flow, available pressure or head, allowable velocities of flow scour, sediment transport, quality of water and relative cost.

4.7.1 Formulae

There are a number of formulae available for use in calculating the velocity of flow. However, Hazen and Williams formula for pressure conduits and Manning's formula for free flow conduits are popularly used :

a) HAZEN - WILLIAMS' FORMULA :

The Hazen - Williams' formula is expressed

$V = 0.849\ CR^{0.63}\ S^{0.54}$

For Circular conduits, the expression becomes

$V = 4.567 \times 10^{-3}\ Cd^{0.63}\ S^{0.54}$
$Q = 1.292 \times 10^{-5}\ Cd^{2.63}\ S^{0.54}$

Where,
Q = discharge in Cu.M per hour
d = Diameter of pipe in mm.
V = Velocity in mps. and
R = Hydraulic radius in m.
S = Slope of hydraulic gradient and
C = Hazen and Williams' Coefficient

The values of Hazen and Williams' Coefficient 'C' (Coefficient of Roughness) for various materials are given in Table 12.

b) MANNING'S FORMULA

$V = (1/n)\ R^{2/3}\ S^{1/2}$

For Circular conduits

$V = 3.968 \times 10^{-3} \times (1/n)\ d^{2/3}\ S^{1/2}$ and

$Q = 8.661\ z\ 10^{-7} \times (l/n)\ d^{2/3} \times S^{1/2}$

Where

Q = discharge in cubic meter per hour
S = Slope of hyraulic gradient
d = diameter of pipe in mm.
R = Hydraulic radius in meters
V = Velocity in mps., and
n = Manning's coefficient of roughness

The co-efficient of roughness for use in Manning's formula for different materials as presented in Table 13 may be adopted generally for design purposes unless local experimental results on other considerations warrant the adoption of any other lower value for the coefficient.

c) DARCY AND WEISBACH FORMULA :

Darcy and Weisbach suggested the first dimensionless equation for pipe flow problem as

$$S = H/L = f\ v^2/2gD$$

Where S = Slope of hydraulic gradient

H = Head loss due to friction over length L

f = Dimensionless friction factor and

g = acceleration due to gravity

The friction factor values in practice for commonly used pipe materials are given in table 14.

Reference may be made to I.S. 2951 for calculation of head loss due to friction according to Darcy-Weisbach Formula.

Table - 12

The value of the Hazen - Williams Coefficient 'C' for various conduit materials and the values to be adopted for design purposes

Conduit Material	Recommended values for	
	New Pipes	Design Purposes
Cast Iron	130	100
Galvanised iron 50 mm	120	100
Galvanised iron 50 mm and below used for house service connections.	120	55
Steel, riverted joints	110	95
Steel Welded joints lined with cement for bituminous enamel.	140	110
Steel Welded Joints	140	100
Concrete	140	110 *
Asbestos cement	150	120 *
Plastic Pipes	150	120 *

These pipe materials are less likely to loose their carrying capacity with age, and hence higher values may be adopted for design purpose, if reliable field data is available to justify such revision.

Table - 13
MANNING'S COEFFICIENT OF ROUGHNESS

Type of lining	Condition	n
Glazed coating of enamel Timber	In perfect Order a) Planed boards carefully laid b) Planed boards inferior workmanship or aged. c) Unplaned boards carefully laid d) Unplaned boards inferior workmanship or aged	0.010 0.014 0.016 0.016 0.018
Masonry	a) Net cement plaster b) Sand & cement plaster c) Concrete, Steel troweled d) Concrete, wood troweled e) Brick in good condition f) Brick in rough condition g) Masonry in bad condition	0.013 0.015 0.014 0.015 0.015 0.017 0.020
Stone Work.	a) Smooth dressed ashlar b) Rubble set in cement c) Fine, well packet gravel	0.015 0.017 0.020
Earth	a) Regular surface in good condition b) In ordinary condition c) With stones & weeds d) In poor condition e) Partially obstructed with debris or weeds	0.020 0.025 0.030 0.035 0.050
Steel	a) Welded b) Riveted c) Slightly tuberculated	0.013 0.017 0.020
Cast Iron		0.013
Asbestos Cement		0.012
Plastic (Smooth)		0.011

For general design purposes, however, the value for all sizes may be taken as 0.013 for plastic pipes and 0.015 for other pipes.

Table - 14

RECOMMENDED FRICTION FACTOR 'f' IN DARCY-WEILSBACH FORMULA

Sl. No.	Pipe Material	Dialmeter(mm) From	To	Friction Factor New	Design period of 30 years
1.	R.C.C.	100	2000	0.01 to 0.02	0.01 to 0.02
2.	A.C	100	600	0.01 to 0.02	0.01 to 0.02
3.	HDPE/PVC	20	100	0.01 to 0.02	0.01 to 0.02
4.	SGSW	100	600	0.01 to 0.02	0.01 to 0.02
5.	C.I (For Corrosive waters)	100	1000	0.01 to 0.02	0.053 to 0.03
6.	C.I (for non-corrosive water)	100	1000	0.01 to 0.02	0.034 to 0.07
7.	Steel	100	2000	0.01 to 0.02	0.01 to 0.04
8.	G.I	15	100	0.14 to 0.30	0.315 to 0.06

4.7.2 Limitations in using Hazen-Williams' Formula

The commonly used Hazen-Williams formula has following inherent limitations :

i) The numerical constant of Hazen Williams formula (1.318 on fps units or 0.85 in mks units) has been calculated for an assumed hydraulic radius of 1 foot and friction slope of 1/1000. However, the formula is used for all ranges of diameter and friction slopes. This practice may result in an error of upto +/-30% in the evaluation of velocity and +/-55% in estimation of frictional resistance head loss.

ii) The Darcy-Weisbach formula is dimensionally consistent. The Hazen-Williams coefficient 'C' is usually considered independent of pipe diameter, velocity of flow and viscosity. However, to be dimentionally consistent and to be representative of friction conditions it must depend on relative roughness of pipe and Reynold's number. A comparison between estimates of Darcy, Weisbach friction factor f, and its equivalent value computed from Hazen - Williams C for different pipe materials brings out the error in estimation of 'f' as, upto +/-45% in using Hazen Williams formula. It has been observed that for higher C values (new and smooth pipes) and larger diameters the error is less whereas, it is appreciable for lower 'C' values (old and rough pipes) and lower diameter at higher velocities.

iii) The Hazen-Williams formula is dimensionally inconsistent,since the Hazen Williams 'C' has the dimension of $L^{-0.37}$ T^{-1} and therefore is dependent on units employed.

4.7.3 Effect of Temperature on Coefficient of Roughness

Analysis carried out to evaluate effect of temperature (viscosity) on value of C_R reveals that the maximum variation of C_R for a temperature range of 10°C to 30°C is 4.5% for a diameter of 2000 mm at a velocity of 3.0 m/s. In the light of this revealation, C_R values are presented for average temperature of 20°C.

4.7.4 Experimental Estimation of C_R Values

The coefficient of roughness in various pipe flow formulae are based on experiments conducted over a century ago. The value of Hazen-Williams C Mannings n, and roughness values in Moody's Diagram have also been based on experimental data collected in early nineteenth century. There have since been major advances in pipeline technology. Both the manufacturing processes and jointing methods have improved substantially over the years and newer pipe materials have come into use. Continued usage of roughness coefficients estimated without recognition of these advances in bound to result in conservative designs of water system.

Accordingly, C_R values of commonly used commercial pipe materials have been experimentally determined in a study conducted at Hyderabad. This study covered pipe diameters of 100 to 1500 mm over a wide range of Reynolds numbers (3×10^4 to 1.62×10^6) encountered in practice. The results bring out that centrifugally spun CI, RCC, AC and HDPE Pipes behave as hydraulically smooth when new and hence $C_R = 1$ for these pipes.

The use of Hazen-Williams 'C', as per Table, results in under utilization of above pipe materials when new. The extent of under utilization varies from 13 to 40 percent for CI Pipes, 23 percent for RCC and AC pipes and 8.4 percent for HDPE/PVC pipes.

4.7.5 Reduction in Carrying Capacity of Pipe with Age :

The values of Hazen-Williams C are at present arbitrarily reduced by about 20 to 23% to cater to reduction in carrying capacity of pipes, with age. A recent study has revealed that chemical and bacteriological quality of water and flow velocity affect the reduction in carrying capacity of pipes with age.

The data on existing system in some cities has been analysed alongwith the experimental information gathered during the study to bring out a rational approach to the reduction in carrying capacity of pipe with age.

The 'C'$_R$ values obtained in this analysis has shown that, except in the case of CI and Steel pipes while carrying corrosive water, the current practice of arbitrary reduction in 'C' values as per para 4.8.1 "coefficient of roughness" results in underutilisation of pipe material to the extent of 38 to 71 percent for CI Pipes for non-corrosive water, 46 to 93 percent for RCC pipes and 25 to 64 percent for AC and HDPE pipes.

4.7.6 Design Recommendations for Use of Modified Hazen-Williams Formula

Following design recommendations are made to ensure effective utilization of pipe carrying capacity.

i) New CI, RCC, AC and HDPE, pipes behave hydraulically smooth and hence C_R of 1 is recommended for design purpose.

ii) For design period of 30 years, no reduction in C_R needs to be effected for RCC, AC and HDPE pipes irrespective of the quality of water. However, care must be taken to ensure self cleansing velocity to prevent formation of slimes and consequent reduction in carrying capacity of these pipes with age.

iii) For design period of 30 years, 15% reduction is required for CI pipes if non-corrosive water is to be transported. The design must also ensure self cleansing velocity.

iv) While carrying corrosive water, CI and steel pipes will loose 47 and 27 percent of their capacity respective over a design period of 30 years. Hence, a cost trade-off analysis must be carried out between chemical and bio-chemical correction of water quality, provision of a protective lining to the pipe interiors and design at reduced C_R value for ascertaining the utility of CI and steel pipe material in the transmission of corrosive waters.

Recommended C_R values are presented in Table 15. The use of recommended C_R values in conjunction with Modified Hazen Williams formula or the nomograph will ensure fuller utilisation of pipe materials.

Table - 15
Recommended C_R Values in Modified Hazen-Williams Formula (AT 20° C)

Sl. No.	Pipe Material	Diameter (mm)		Velocity M/s		C_R value when new	C_R value for design period of 30 years
		From	To	From	To		
1.	R.C.C.	100	2000	0.3	1.8	1.00	1.00
2.	A.C	100	600	0.3	6.0	1.00	1.00
3.	HDPE/PVC	20	100	0.3	1.8	1.00	1.00
4.	C.I (For water with positive Langelier's Index)	100	1000	0.3	1.8	1.00	1.85*
5.	C.I (For waters with negative Langelier's Index)	100	1000	0.3	1.8	1.00	0.53*
6.	Steel (For waters with negative Langelier's Index)	100	2000	0.3	2.1	1.00	0.73*
7.	SGSW	100	600	0.3	2.1	1.00	1.00
8.	G.I (For waters with positive Langelier's Index)	15	100	0.3	1.5	0.87*	0.74

* These are average C_R values which result in a maximum error of +/- 50% in estimation of surface resistance.

4.7.7 Resistance due to Specials and Appurtenances

Pipeline transitions and appurtenances add to the head losses, which are expressed as velocity heads as $K V^2/2g$ where V and g are in m/s and m/sec^2 respectively or equivalent length of straight pipe. The values of K to be adopted for the different fittings are given in Table 16.

Table - 16
'K' Values for Different Fittings

Type of fitting	Value of K
Sudden Contractions	* 0.30 - 0.50
Entrance shape well rounded	0.50
Elbow 90°	0.50 - 1.00
45°	0.40 - 0.75
22°	0.25 - 0.50
Tee 90° take off	1.50
Straight run	0.30
Coupling	0.30
Gate Valve (Open)	** 0.30 - 0.40
With reducer and increaser	0.50
Globe	10.00
Angle	5.00
Swing Check	2.50
Meter venturi	0.30
Orifice	1.00

* Varying with area ratio
** Varying with radius ratio

4.7.8 Modified Hazen-Williams Formula

The modified Hazen Williams formula has been derived from Darcy-Weisbach and Colebrook-White equations and obviates these limitations of Hazen-Williams Formula

$$V = \frac{3.83\ Cr\ d^{0.6575}\ (gs)^{0.5525}}{u^{0.105}}$$

Where

V = Velocity in mps.
d = Pipe diameter
s = Friction slope
Cr = Coefficient of roughness
g = Acceleration due to gravity (i.e.9.81 m/s^2)
u = Viscosity of liquid

For circular conduits, value of u at 20^0c for water is $10^{-6} m^2/s$

The modified Hazen-Williams formula is derived as

$$V = 143.534\, C_R\, r^{0.6575}\, s^{0.5525}$$

$$h = \frac{L\,[Q/C_R]^{1.81}}{994.62\, D^{4.81}}$$

in which,
V = Velocity of Flow in M/S
C_R = Pipe roughness coefficient, (1 for smooth pipes, < 1 for rough pipes)
r = hydraulic radius in m.
s = friction slope
D = internal diameter of pipe in m.
h = friction headloss in m.
L = Length of pipe m. and
Q = Flow in pipe, in m/s.

4.7.9 Economic Size of Conveying Main

General considerations :

When the source is separated by a long distance from the area of consumption, the conveyance of the water over the distance involves the provision of a pressure pipeline or a free flow conduit entailing an appreciable capital outlay and therefore it is important to have the most economical arrangement for the conveyance.

The available fall from the source to the town and ground profile in between, should generally help to decide if a free flow conduit is feasible. Once this is decided, the material of the conduit is to be selected keeping in view the local costs and the nature of the terrain to be traversed. Even when a fall is available, a pumping or force main, independently or in combination with gravity main could also be considered. Optimisation techniques need to be adopted to help decisions. The most economical size for the conveyance main will be based on a proper analysis of the following factors:

a) the period of design considered or the period of loan repayment if it is greater than the design period for the project and quantities to be conveyed during different phases of such period.

b) the different pipe sizes against different hydraulic slopes which can be considered for the quantity to be conveyed.

c) the different pipe material which can be used for the purpose and their relative costs as laid in position.

d) the duty, capacity and installed cost of the pump sets required against the corresponding sizes of the pipelines under consideration.

e) The recurring costs on

i) energy charges for running the pump sets.
ii) staff for operation of the pump sets.
iii) cost of repairs and renewals of the pump sets.
iv) cost of miscellaneous consumable stores.

f) Cost of replacement of the pumpsets installed to meet the immediate requirements, by new sets at an intermediate stage of design period. The full design period or the repayment period may be 30 years or more while the pumpsets are designed to serve a period of 15 years.

g) Cost of small pipe differ marginally and hence unnecessary tight designs are not desirable.

4.8 OPERATION PROCEDURE

(1) Rotational water Supply
(2) On Demand Water Supply

4.8.1 Rotational Water Supply

In our country, generally rotation method is followed which include constant frequency and either constant amount or varied amount.

In rotation method the water is delivered at a fixed time on prearranged schedule. Rotation may be made between.

(i) Two water users
(ii) Two or more groups of water users
(iii) Outlets
(iv) Distributaries and minors
(v) Definite sections of main canal.

4.8.2 On Demand Water Supply

The farmer has to apply for water in advance atleast 48 hours. The supply in the main pipeline and lateral will be fully charged at designed discharge. The system is designed to complete all irrigation period of 7 days. The demands are adjusted to suit 7 days working period. For this type of operation the diameter of pipe and design discharge are required to be kept on higher side. The cost of the system is also high. Thus the system is not suitable for adoption due to cost constraints.

CHAPTER - 5

COST ECONOMICS

5.1 COST ECONOMICS - METHODOLOGY

5.1.1 Pipe length, type of material, fittings, excavation soil conditions, equipments requirement should be considered while estimating the cost.

Information in respect of following items (Table 17) is useful to estimate the correct cost.

Table 17
Information to be collected for Cost Economics

Sl.No.	Item	Purpose
1.	Length of Pipe	To determine number of joints
2.	Number of Joints	To determine labour & material.
3.	Weight of Pipe	Equipment required to handle.
4.	Water Table Position	Pumping requirement.
5.	Soil Data	Sheet piling, trench box shoring requirement.
6.	Excavation Methods	To determine by manually or machinery.
7.	Value and hydrant support.	Forms and setting labour components.
8.	Bedding and backfill	Material, Labour and transport.
9.	Excavate trench material	Removal and planning.
10.	Joining materials and equipment required.	To determine resins, glues fusion machines.
11.	Trench depths	To determine requirement of shoring sheet piling.
12.	Pipe, fitting, valves etc.	Material and fabrication
13.	Transportation	Material and unloading labour
14.	Instrumentation	Setting and caliberation.
15.	Major equipments and machinery	Labour and material
16.	Special T. and P.	To determine rental and allied requirement.
17.	Testing	Equipment determination

Cost stability can be achieved, if the work is started at the earliest after receiving sanction from competent authority.

5.1.2 The total cost of pipe line distribution involves 80% of the material cost. It involves cost of pipes, pumps, fittings, specials, valves, jointing materials, back fill material etc.

Annual maintenance cost can be minimised if the system is executed as per design.

Maintenance cost being recurring expenditure shall be kept to minimum.

5.2 DIFFERENT METHODS OF B.C. RATIO

For pipeline distribution system, the following methods may be adopted for economic evaluation:

1) Benefit Cost Ratio

2) Economic Rate of Return (ERR)

5.2.1 Benefit Cost Ratio

Ten percent return on investment of capital cost, depreciation and annual maintenance and repair cost may be considered for working out annual cost.

Besides irrigation, other benefits such as industrial, local water supply etc.should also be accounted for.

Part of capital cost invested to create main source of supply should be proportionately debited to that part.

It is expected that maximum benefits are derived from the scheme.

Ideally economic comparison should be for conversion of existing field channel distribution system to a pipe distribution system,Cost of headworks and main canal remaining unchanged.

However, B.C. ratio may have to be calculated as per procedure given in the guidelines for preparation of detailed project report of irrigation and multipurpose projects (Working Group Report 1980 of Ministry of Irrigation). According to the guidelines the following are the main components to be considered for calculation of B.C. ratio.

1. (a) Estimated cost of the project.

(b) Cost of land development

2. Annual Benefits

(a) Gross value of the produce post project.
(b) Gross value of the produce pre-project.

3. Annual Cost

(a) Interest at 10% of the estimated total cost of the project.
(b) Depreciation of the project at 1% of the cost of the project.
(c) Depreciation of the pumping system at 8.33% of the estimated cost of the pumping system.
(d) Depreciation if the rising mains at 3.33% of the estimated cost.
(e) Charges of the power for lift irrigation (where applicable)
(f) Annual operation & Maintenance Charges at Rs 180/- per ha
(g) Maintenance of head works at 1% of its cost.

4. B.C. Ratio = $\dfrac{\text{Net Value of Benefit}}{\text{Annual Cost}} > 1.5$

The B.C. Ratio, therefore may be worked out considering the project in totality and not the pipeline component alone or separately.

5.3 ECONOMIC ANALYSIS

Different engineering schemes required to meet the same objectives may be compared economically in a number of ways. If all payments and incomes associated with a scheme are discounted to their present value for comparison, the analysis is termed a present value or discounted cash flow analysis. On the other hand, if annual net incomes of different schemes are compared, this is termed as the rate of return method. The latter is most frequently used by private organisations where tax returns and profits feature predominate. In such cases, it is suggested that the assistance of qualified accountants is obtained. Present value comparisons are most common for public utilities.

A form of economic analysis popular in the United States is benefit/cost analysis. An economic benefit is attached to all products of a scheme, for instance a certain economic value is attached to water supplies, although this is difficult to evaluate in the case of domestic supplies. Those schemes with highest benefit/cost values are attached highest priority. Where schemes are mutually exclusive such as is usually the case with public utilities,the scheme with the largest present value of net benefit is adopted. If the total water requirements of a town for instance were fixed, the least cost supply scheme would be selected for construction. Inclusion of residual value of the system certainly tends to improve the economic viability.

5.3.1 Economic Rate of Return (E.R.R.) - Basic of Economics

Economics is used as a basis for comparing alternative schemes or designs. Different schemes may have different cash flow necessitating some rational form of comparison. The crux of all methods of economic comparison is the discount rate which may be in the form of the interest rate of loans or redemption funds. National projects may require a discount rate different from the prevailing interest rate, to reflect a time rate of preference, whereas private organizations will be more interested in the actual cash flows, and consequently use the real borrowing interest rate.

The cash flows i.e. payments and returns, of one scheme may be compared with those of another by bringing them to a common time basis. Thus all cash flows may be discounted to their present value. For instance, present value of one dollar to be received next year will be \$ 1/1.05, if it could earn 5% interest on investment of this year. It is usual to meet capital expenditure from a loan over a definite period at a certain interest rate. Provision is made for repaying the loan by paying into a sinking fund which also collects interest. The annual payment at the end of each year required to amount of \$1 in n year is

$$\frac{n}{(1+r)^n - 1}$$

Where r is the interest rate on the payment into the sinking fund. If the interest rate on the loan is R then the total annual payment is

$$\frac{R(1+r)^n + r - R}{(1+r)^n - 1}$$

Normally the interest rate on the loan is equal to the interest rate earned by the sinking fund so the annual payment on a loan of \$ is

$$\frac{r(1+r)^n}{(1+r)^n - 1}$$

Conversely, the present value of a payment of \$1 at the end of each year over n year is

$$\frac{(1+r)^n - 1}{r(1+r)^n}$$

The present value of a single amount of $1 in n year is

$$\frac{1}{(1+r)^n}$$

Interest tables are available for determining the annual payment on loans, and the present values of annual payments or returns, for various interest rates and redemption periods.

5.4 EVALUATION

Evaluation is a process of knowing merits and demerits, advantages or disadvantages, good or bad qualities or particular event, situation, system of whatsoever.

In the context of pipe line distribution system, the evaluation can be done after successful launching of the system. Following terms can be applied while evaluating the scheme.

a) Performance and necessity of system
b) Utility of System and acceptance by beneficiaries
c) How maximum benefits derived from system
d) Extent of increase in awareness
e) Feedback of beneficiaries
f) Comparative advantage both tangible and intangible over previous irrigation methods.

Parameters for evaluation should be determined very carefully. It will facilitate to derive unbiased outcome evaluation process, subject to pipeline distribution system.

5.5 LIMITATIONS OF ECONOMIC ANALYSIS

Forecasts of demands, whether they be for water, oil or gas, are invariably clouded with uncertainty and risk. Strictly,a probability of analysis is required for each possible scheme i.e the net benefit of any particular scheme will be the sum of the net benefits multiplied by their probability for a number of possible demands. Berthoues (1971) recommends under-designing by 5 to 10% for pipelines to allow for uncertain forecasts, but his analysis does not account for cost inflation.

An alternative method of allowing for uncertainty is to adjust the discount or interest rate, increasing the rate will favour a low capital cost scheme, which would be preferable if the future demands were uncertain.

CHAPTER - 6

CONSTRUCTION AND TESTING TECHNIQUES

6.1 PIPE SPECIFICATIONS

The selection of material for pipe changes according to soil data, situation, pressures, temperatures etc. Specifications drafted as per requirement should cover the information for the use of engineer, buyer, supplier and installer I.S.I. Codes shall be referred for further guidelines. Manufacturers should have basic specifications to suit the purchaser's general requirement.

Following guide lines should be taken into account for drafting specifications:

a) Identify system requirement

b) Specifications should be simple and meaningful

c) As far as possible, specifications should not confuse with general manufacturers' products.

d) Use the words which are simple and understandable, misinterpretation can lead to legal consequences.

e) Specifications for valves involve complexity,therefore it shall be included in separate documents.

f) Valve specifications should include size, range, identification, gears, indicators, coating, dimensions.

g) Pipe specifications should include, size description, purpose or service pressure rating, temperature range, flow coefficient C (Hazen Williams), Test pressure, corrosion allowance, pipe length, thermal co-efficient of expansion etc.

6.1.1 Basis of Acceptance

The acceptability of the pipe line shall be determined by inspections to check compliance with all the provisions of this standard with respect to the design of the line and appurtenance used and the minimum installation requirements.

6.1.2 Certification and Guarantee

Generally all materials shall confirm to these minimum requirements and to the tests prescribed in the applicable ASTM Standards.

When required, the pipe shall be certified by a qualified testing Laboratory for compliance with the requirements set out in prescribed manufacturing Standard.

When mutually agreed by the purchaser and the contractor, the installing contractor shall certify that his installation complies with the requirements of prescribed standard. He shall furnish written guarantee to protect the owner against defective workmanship and materials over a period of not less than one year.

6.1.3 Plans and Specifications

General Plans and Specifications for construction of underground thermoplastic irrigation pipelines shall be in keeping with prescribed standard and shall describe the requirements for application of the practice to achieve its intended purpose.

1. Selpt W.R., 1974 Water Hammer Considerations for PVC Pipeline in Irrigation System. TRANSACTION OF the A.S.A.E. 17(3) : 417-423.

2. ASTM D 1248 Specification for Polyethylene Plastic Molding and Extrusion Materials.

3. ASTM D 1598 Test for time-to failure of Plastic Pipe under Long term Hydrostatic Pressure.

4. ASTM D 1784 Specification for Rigid Poly Vinyl Chloride compounds and chlorinated poly Vinyl chloride compounds.

5. ASTM D 1788 Specification for Rigid Acryloalcrile-Hutandiene System (ABS) Plastics.

6. ASTM D 1788 Specification for Rigid.

7. ASTM D 2122 Determining Dimensions of Thermoplastic Pipe and Fittings.

8. ASTM D 2230 Specification for Polyethylene (PE) Plastic Pipe (SDE-PR)

9. ASTM D 2235 Specification for Solvent cement for Acrylonitrile-Butadiene-Systems (ABS) Plastic pipe & fittings.

10. ASTM D 2241 Specification for Poly Vinyl chloride (PVC) Plastic Pipe (SDR-PR and PR and Class T)

11. ASTM D 2282 Specification for Acrylonltrile-Butaduene-Systems (ABS) Plastic Pipe (SDR-PR and Class T).

12. ASTM D 2444 Test for Impact Resistance of Thermoplastic Pipe and Fittings by means of a Tap (Falling Weight).

13. ASTM D 2466 Specification for Socket-Type Poly Vinyl Chloride (PVC) Plastic Pipe Fittings Schedule 40.

14. ASTM D 2467 Specification for Socket-Type Poly Vinyl Chloride (PVC) Plastic Pipe Fittings Schedule 80.

15. ASTM D 2468 Specification for Socket-Type Acrylonltrile Butadiene System(ABS) Plastic Pipe Fittings, Schedule 40.

16. ASTM D 2469 Specification for Socket-Type Acrylinltrile-Butadiene-System(ABS) Plastic Pipe Fittings, Schedule 80.

17. ASTM D 2564 Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

18. ASTM D 2609 Specification for Plastic Insert Fittings for Polythylene (PE) Plastic Pipe.

19. ASTM D 2610 Specification for Butt Fusion Polyethylens (PE) Plastic Pipe Fittings, Schedule 40.

20. ASTM D 2611 Specification for Butt Fusion Polyethylene (PE) Plastic Pipe Fittings, Schedule 80.

21. ASTM D 2672 Specification for Bell-End Poly Vinyl Chloride (PVC) Pipe.

22. ASTM D 2774 Recommended Practice for Underground Installation of Thermoplastic Pressure Piping.

23. ASTM D 2837 Obtaining Hydrostate Design Basis for Thermoplastic Pipe Materials.

of cement, then along side it a thin brushed out layer. Test the layers every 15 seconds or so by a gentle tap with your finger. You will note that the thin layer becomes tacky and then dries quickly (probably within 15 seconds). The heavy layer will remain wet much longer. Now check for penetration a few minutes after applying these layers. Scrape them with a knife. The thin layer will have achieved little or no penetration and the heavy one much more penetration.

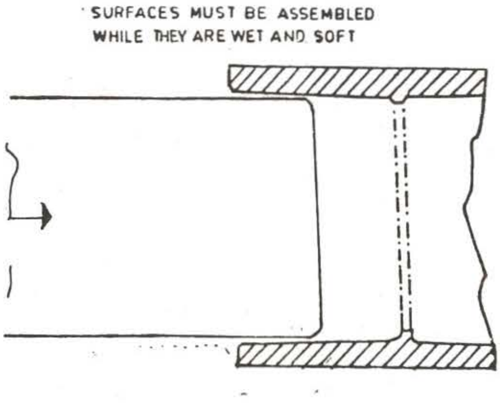


Fig. 23 Assembling of Surfaces while wet and soft

If the cement coatings on the pipe and fittings are wet and fluid when assembly takes place they will tend to flow together and become one cement layer. Also, if the cement is wet, the surfaces beneath them will still be soft, and these softened surfaces in the tight part of the joint will tend to fuse together (Fig. 23).

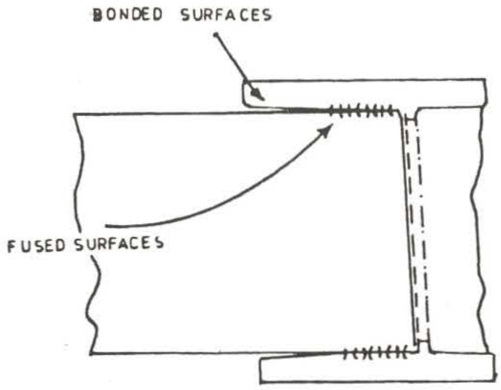


Fig. 24 Bonded surfaces/fused surfaces

As the solvent dissipates, the cement layer and the softened surfaces will harden with a corresponding increase in joint strength. A good joint will take the required working pressure long before the joint is fully dry and final strength is obtained. In the tight (fused) part of the joint (Fig.24) strength will develop more quickly than in the looser (bonded) part of the joint. Information about the development of bond strength of solvent cemented joints is available.

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22. ASTM D 2774 Recommended Practice for Underground Installation of Thermoplastic Pressure Piping.

23. ASTM D 2837 Obtaining Hydrostate Design Basis for Thermoplastic Pipe Materials.

24. ASTM D 3036 Specification for Poly Vinyl Chloride (PVC) Plastic Line Couplings, Socket Type.

25. ASTM D 3139 Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastromeric Seals.

6.2 CONSTRUCTION SPECIFICATIONS

These specifications shall observe reference to the national standards, specifications and codes in effect at the time of buyers' request for material/ labour or during construction.

6.2.1 Handling and Receiving

Inspection of pipes, fittings and valves shall be done in accordance with the standards and requirements as directed by Site-in-Charge. Defective materials shall be recorded in writing and are liable for rejection.

Any defects i.e. cracks, fractures, pin holes, chips, breaks, damage in any item caused by faulty fabrication or manufacture or by transportation will be liable for rejection.

Stacking, unloading and handling shall be done strictly in accordance with manufacturer's instructions.

6.2.2 Installation Requirement

6.2.2.1 The thermoplastic pipe shall be installed in accordance with the manufacturers' recommendations. If these are not available, then ASTM D2774 Recommended Practice for underground installation of Thermoplastic pressure Pipings, for pipe 152 mm (6 inches) diameter or less, shall be followed.

6.2.2.2 Placement - Special handling and an awareness of temperature effects on thermoplastic pipe are needed to prevent permanent distortion and pipe damage when handling during unusually warm or cold weather. The pipe shall be allowed to come to within a few degree of the temperature that it will have after complete covering prior to any backfilling beyond shading and prior to connecting to other facilities.

The pipeline shall be installed to provide protection from hazards imposed by traffic crossing, farming operations, freezing temperatures or soil cracking. At low places on the ground surface extra fill may be placed over the pipeline to provide the minimum depth of cover. In such cases, the top width of the fill shall not be less than 3 m (10 ft) and the side slope not steeper than 6 horizontal to 1 vertical.

6.2.3 Minimum depth of cover shall be as follows :

(i) For pipes 13 to 64 mm (0.5 to 2.5 in.) diameter, a minimum depth of cover of 457 mm (18 in.).

(ii) For pipes 64 to 102 mm. (2.5 to 4 in.) diameter, a minimum depth of cover of 610 mm (24 in.).

(iii) For pipes over 102 mm. (4 in) diameter, a minimum depth of cover of 762 mm. (30 in).

6.2.4 Maximum depth of cover for low head pipe shall be 1.2 m. (4 ft.). For other classes of pipe, the manufacturer should be consulted for maximum depths of cover.

6.3 TYPES OF PIPES AND THEIR SPECIFICATIONS.

6.3.1 The pipes are available in different lengths ranging from 2 m. to 8 m. RIBLOCK pipes can be manufactured at work site to any length depending upon site requirements. Pieces of smaller lengths can be cut through the available pipes. However, connection between two pipes will have to be scientifically thought over. Various types of jointing Connections of tees, bends and other special need enlarged couplings can be adopted for this purpose.

6.3.2 Joints

All joints shall be constructed to withstand the design maximum working pressure for the pipeline without leakage and shall leave the inside of the line free of any obstruction that may tend to reduce its capacity below design requirements. manufacturers' recommendations for joining pipe shall be used when not in conflict with requirements specified by the organisation.

6.3.3 Socket and Couplings

The integral bell or separate coupling shall meet the same strength requirements as the pipe. When joint assembly requires use of separate couplings, one such coupling of the same class and size shall be furnished with each length of pipe.

6.3.4 Solvent Cement

Solvent cement for use with P.V.C. Pipe and fittings only shall meet the requirements of ASTM D2564, specifications for Solvent cement for PVC. Solvent cements for ABS plastic pipe and fittings only shall meet the requirements of ASTM D2235.

6.3.5 Rubber Gasket Joints

Rubber gasket joints shall conform to ASTM D3139 "Specifications for joints for plastic pressure pipes using Flexible Elastomeric seals".

6.3.6 Plastic Risers

Plastic risers shall have at least the same strength as the pipe. Risers with use limited to sub-surface attachment are covered by this standard.

6.3.7 Fittings Requirements

Fittings for IPS Sized pipe shall meet all the dimensional and quality requirements given in the following applicable ASTM Standards.

D2466 : PVC Plastic Pipe Fittings, Socket Type Schedule 40
D2467 : PVC Plastic Pipe Fittings, Socket Type Schedule 80
D2468 : ABS Plastic Pipe Fittings, Socket Type Schedule 40
D2469 : ABS Plastic Pipe Fittings, Socket Type Schedule 80
D2609 : PE Plastic Insert Fittings.
D2610 : PE Butt Fusion Plastic Pipe Fittings, Schedule 40
D2611 : PE Butt Fusion Plastic Pipe Fittings, Schedule 80
D2672 : Bell End PVC Plastic Pipe
D3036 : PVC Plastic Line Couplings, Socket Type

6.3.8 Basic Principles of Solvent Cementing Plastic Pipe and Fittings.

The solvent cemented connection in thermoplastic pipe and fittings is the last vital link in a plastic pipe installation. It may cause the success or failure of the systems as a whole. Accordingly, it requires the same professional care and attention that are given to other components of the system.

There are many solvent cementing techniques published covering step by step procedures on just how to make solvent cemented joints. However, we feel that if the basic principles involved are explained, known and understood, a better understanding would be gained, as to what techniques are necessary to suit particular applications, temperature conditions, and variations in sizes and fits of pipe and fittings.

To consistently make good joints, the following points should be clearly understood.

- The joining surface must be softened and made semi-fluid.
- Sufficient cement must be applied to fill gap between pipe and fitting.

- Assembly of pipe and fittings must be made while the surfaces are still wet fluid.

- Joint strength develops as the cement dries. In the tight part of the joint, the surfaces will tend to fuse together. In the loose part, the cement will bond to both surfaces.

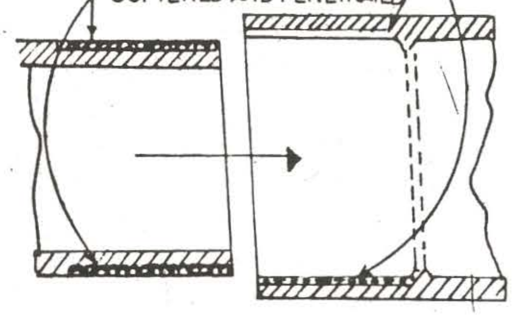


Fig. 21 Penetration and Softening

Penetration and softening (Fig.21) can be achieved by the cement itself, by a suitable primer, or by the use of both primer and cement. For certain materials and in certain situations, it is desirable to use a primer. A suitable primer will usually penetrate and soften the surface more quickly than the cement alone. Additionally, the use of a primer can provide a safety factor for the installer, he can know under various temperature conditions when surfaces achieve sufficient softening. For example, in cold weather more time and additional applications are required.

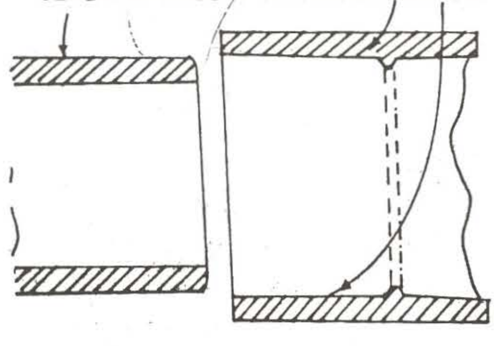


Fig. 22 Cement coating of sufficient thickness

More than sufficient cement must be applied to fill the loose part of the joint. Besides filling the gap, adequate cement layers will penetrate the surfaces and also remain wet untill the joint is assembled (Fig 22). Prove this for yourself. Apply on the top surface of a piece of pipe two separate layers of cement. First flow on a heavy layer of cement, then along side it a thin brushed out layer. Test the layers every 15 seconds or so by a gentle tap with your finger. You will note that the thin layer becomes tacky and then dries quickly (probably within 15 seconds). The heavy layer will remain wet much longer. Now check for penetration a few minutes after applying these layers. Scrape them with a knife. The thin layer will have achieved little or no penetration and the heavy one much more penetration.

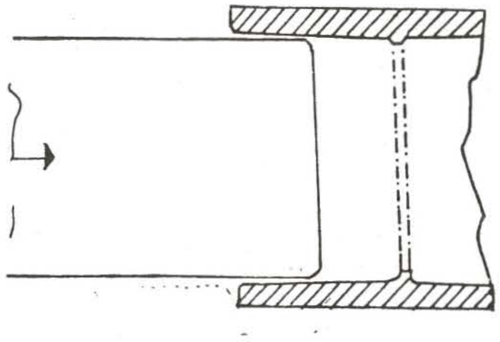


Fig. 23 Assembling of Surfaces while wet and soft

If the cement coatings on the pipe and fittings are wet and fluid when assembly takes place, they will tend to flow together and become one cement layer. Also, if the cement is wet, the surfaces beneath them will still be soft, and these softened surfaces in the tight part of the joint will tend to fuse together (Fig. 23).

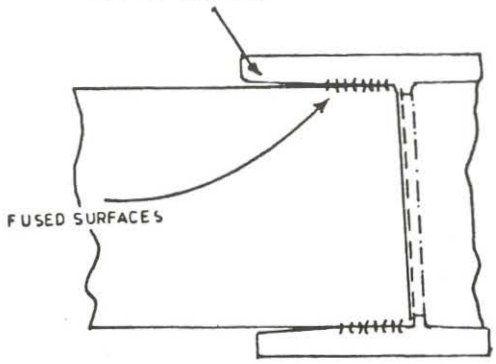


Fig. 24 Bonded surfaces/fused surfaces

As the solvent dissipates, the cement layer and the softened surfaces will harden with a corresponding increase in joint strength. A good joint will take the required working pressure long before the joint is fully dry and final strength is obtained. In the tight (fused) part of the joint (Fig.24) strength will develop more quickly than in the looser (bonded) part of the joint. Information about the development of bond strength of solvent cemented joints is available.

6.4 TESTING SPECIFICATIONS

The pipe line shall be thoroughly and completely tested for pressure strength and leakage before backfill operations are undertaken. If it is necessary to partially backfill the line before testing to hold the line in place, the partial backfill shall be undertaken as specified.

Only the body of the pipe sections shall be covered with all joints and connections left uncovered for inspection.

6.4.1 Filling

The line shall be slowly filled with water. The velocity of water input shall not exceed 0.3 m/s(1 ft/s). Adequate provision shall be made for air release while filling taking care to bleed all entrapped air in the process. The pressure shall be slowly built upto the maximum design working pressure. Pressurising should take at least 10 minutes for pipe lines 102 mm (4 in) and smaller in diameter and having a test pressure of 689 Kpa (100 psi) in a test section of 305 m (1000 ft). For larger diameter, longer lines and higher pressures,proportionately longer build up times shall be used.

6.4.2 Inspection

The pipe line shall be inspected in its entire length while the maximum working pressure is maintained. Where leaks are discovered they shall be promptly repaired and the line retested.

6.4.3 Flow Capacity

It shall be demonstrated by testing that the pipe line will function properly at design capacity, at or below design capacity there shall be no objectionable surge or water hammer.

6.4.4 Objectional Flow Condition

Objectional flow during testing condition shall include continuing unsteady delivery of water, damage to the pipe line, detrimental overflow from vents or stands or sudden or rapid changes in flow velocity at either start up or shut down including emergency shut off particularly in lines appreciably longer than 305 m (1000 ft).

6.4.5 Testing Procedure

Section of pipe line properly laid and jointed shall be tested for water tightness before it is covered. Generally 300 metre lengths preferably between valves is considered for testing at a time.

The pipe trench may be partially filled during testing whereas all joints shall be kept uncovered.

Open end of pipe line shall be closed by fitting a plug.

Pipes shall be slowly filled with water so that all air shall be expelled from pipes through hydrants.

During testing, if joints are showing leakages it shall be made water tight or replaced, if necessary. Repaired joints shall again be retested.

During test the pipes should be struck with small hammer to detect cracks.

All pipes, fittings, valves should be examined for defects.

No pipe installation shall be accepted unless it is less than or equal to permissible leakages.

6.5 CONSTUCTION MANUAL

A concrete pipe irrigation system represents substantial investment. For best results, the system should be properly designed and constructed. Proper installation of quality concrete pipe line is the key to trouble free service. Main points to be kept in mind are discussed below.

6.5.1 Grade and Alignment

Pipe lines should be straight and of uniform gradient from reach to reach or between stands.

6.5.2 Excavation

Trenches should be reasonably straight with the bottom free of undulations and humps. To minimise cost, all trenches should be excavated with vertical sides and a well graded bottom. All excavated material should be deposited on one side of the trench and the pipe placed on the other side. All pipe should be placed deep enough below the land surface, to protect them from hazards of traffic crossing, farm operations, freezing temperature and soil cracking. Minimum depth should not be less than 0.6 m where trenches excavated in soils containing rock or other materials or in soils subject to appreciable swelling and shrinking on wetting and drying or where the trench bottom is unstable, the trenches should over excavated and back filled with selected materials to sufficient depth (100-150 mm) to provide a suitable base. If water is in the trench, it should be drained away or controlled in a manner to prevent damage to the joint morter and to maintain a suitable base. The width of the trench should be sufficient to permit the laying of pipes correctly and for proper bonding or finishing of joints. There should be a minimum clearance of 150 mm from the outside of the pipe to the sizes of the trench, for pipes upto and including 400 mm in diameter and a clearance of from 200 to 300 mm on each side for larger pipes. The bottom of the trench should be graded and prepared to provide a firm and uniform bearing throughout the entire length of the pipe. The bottom of the trench should be shaped to fit the lower part of the conduit exterior for a width of at least 50% of the external diameter of the conduit. All boulders and stones larger than 25 mm should be removed from the subgrade to a depth of 100 mm below the bottom of the pipe.

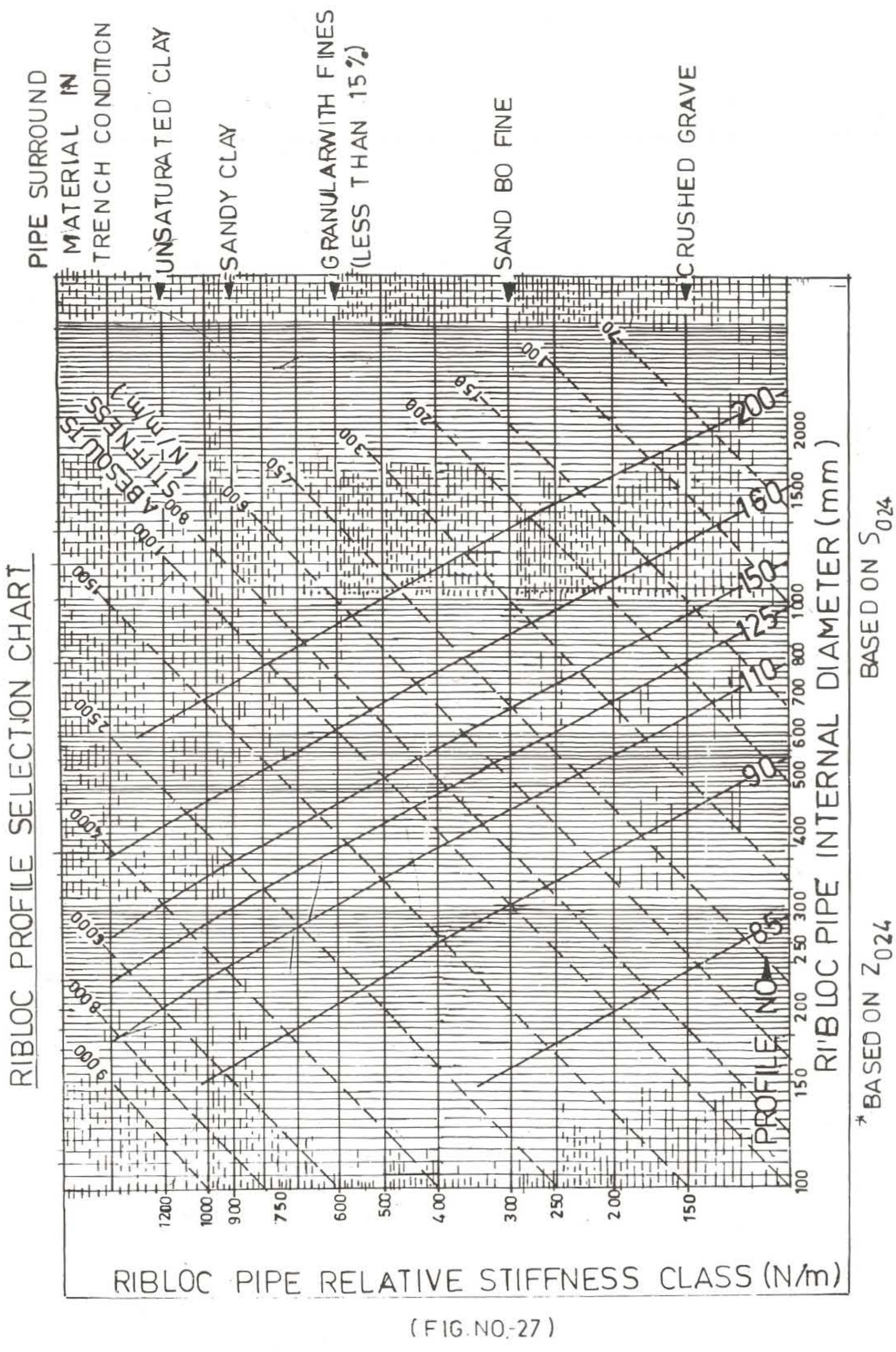
6.5.3 Placement

When the pipes are laid, the prepared trench should be in a reasonably dry condition. Pipes should be lowered properly without any damage. The interior of the pipes should be kept free from dirt and other foreign material as the pipe laying progresses and left clean at the completion of the work. Any pipe which is not in true alignment or which shows any undue settlement after laying or is damaged should be taken up and relaid. Curves are permitted with a maximum deflection of five degrees in morter joints and a maximum of three degrees in rubber gasket pipe, with all joints receiving an equal amount of deflection.

6.6 USE OF PERT AND CPM

In order to achieve desired progress of construction work within stipulated time, the PERT and CPM charts should be prepared. It shall include, list of construction activities, estimate of time requirement, sequence of activities, flow diagrams, mile stone, list of events etc.

Updating and review of each activity should be undertaken.



(FIG.NO.-27)

Fig. 27 RIBLOC profile selection chart

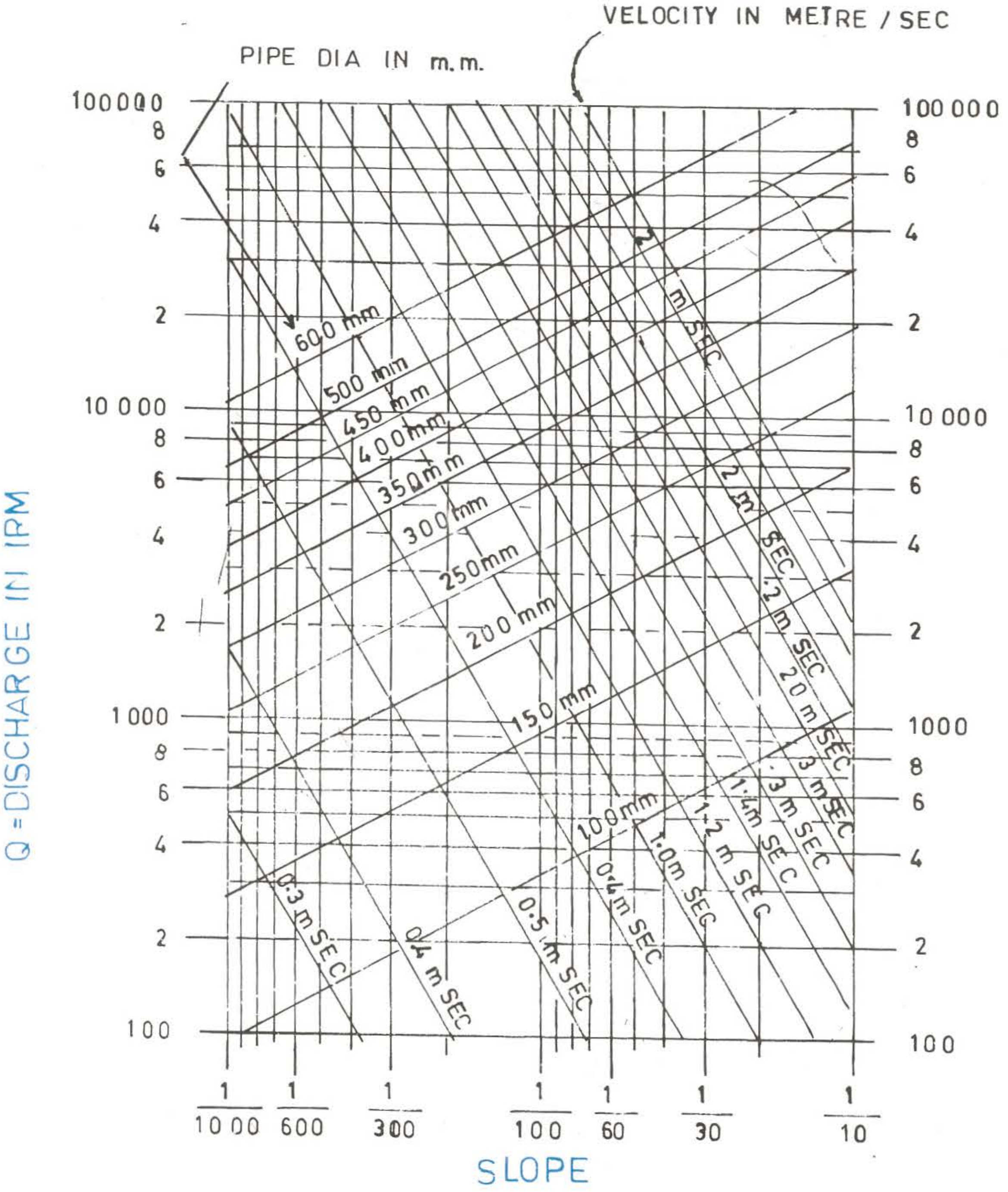


Fig. 28 Nomogram Chart of Hazen-Williams formula C-100 (Pipe dia upto 600 mm)

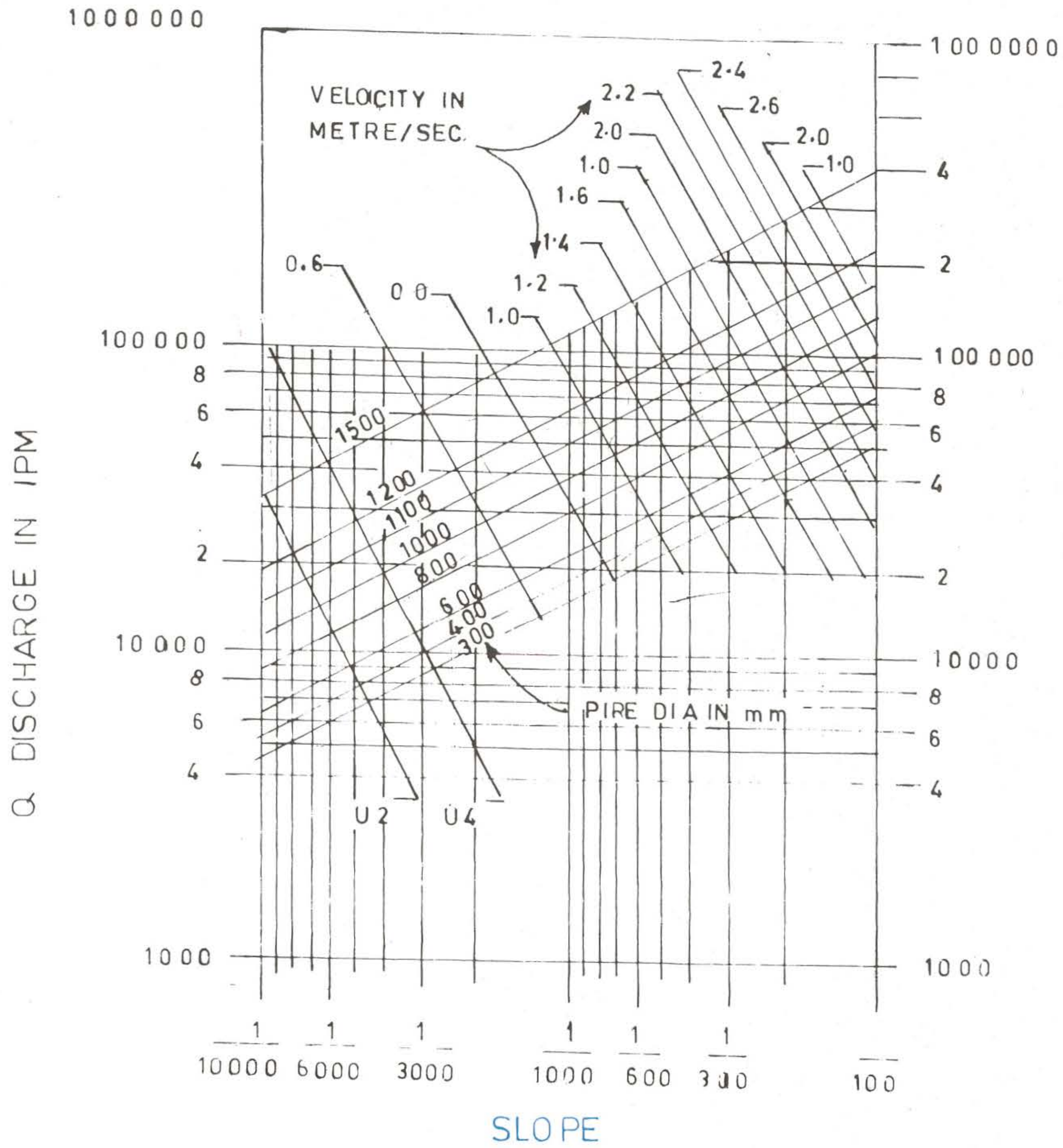
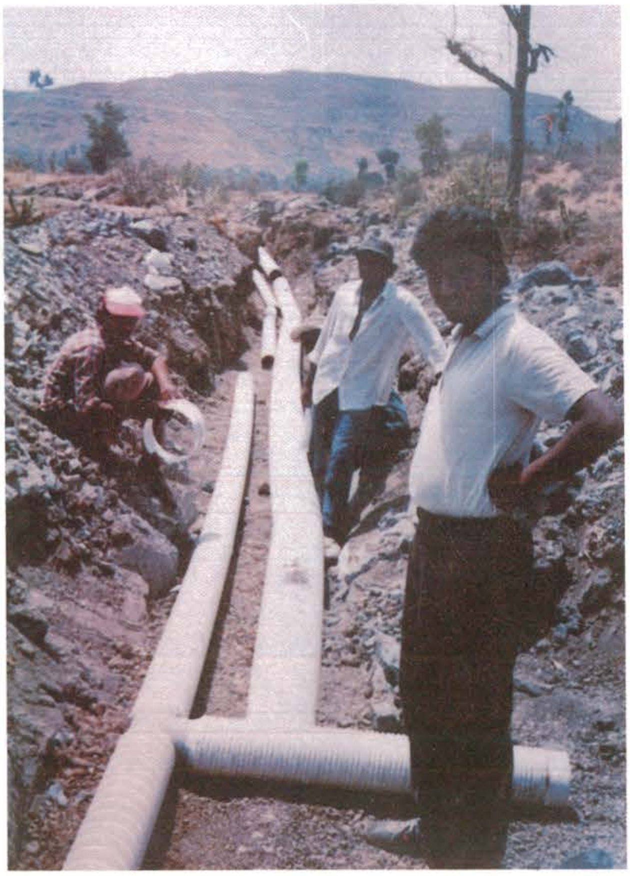


Fig. 29 Nomogram Chart of Hazen-Williams formula C-100 (Pipe dia upto 1500 mm)



Laying of Pipes for Lateral - 3.

Concrete casing due to low depth at ch. 520 m.

CHAPTER - 7

OPERATION AND MAINTENANCE

7.1 OPERATION GUIDELINES

After the pipe line system is installed and tested, responsibility of those who have to operate and maintain is started.

To facilitate easy operation and maintenance,following instructions and data shall be taken into account :

a) Drawings
b) Test details
c) Equipments Information
d) Operating Schedules & Instructions
e) Spare Part List
f) Pipe and Valve specifications
g) Soil, data G.W.T. etc.

For sump, catch basin, traps, regular cleaning schedules should be prepared.

Sharp devices like cutters, scrapers, rods etc. should not be used while handling plastic pipe lines.

Hydro jets (High pressure Water Cleaners) can be used if system is plugged.

Valves, hydrants and other devices projecting above the ground should be protected by guard posts to avoid any damage. In case of underground pipes, valves should be operated regularly. Indicators shall be kept for all buried valve. Required training should be given to operating personnel.

7.1.1 Operation should be such that it should work with full efficiency for wide range of variation in discharge. Sudden closing of valves and opening should be avoided. Sequence of opening and discharges should be as per operation schedule.

For efficient operation,measurement of discharges at various points will be controlling factor.

7.2 REPAIRS MANUAL

a) General repairs should be carried out by experienced and trained persons.

b) Maintenance personnel should be familiar with the leak detecting tools viz. Pipe locating devices, Repair Clamps, Repair Couplings.

c) Cracks, breaks, debris and infiltration leaks etc. should be located and repaired.

Repairs to PVC pipes in the trench with both ends fixed and both ends open has been highlighted in Fig. 35 & 36.

7.3 MAINTENANCE MANUAL

1) Current repairs or ordinary repairs and special repairs are generally carried out as and when necessary.
2) Keeping sufficient stock of spares, timely insepction to locate leakages, observation of discharge security and protection of pipe line are main guiding factors for maintenance purpose.

Format for typical inspection is given in Table 18.

7.4 OPERATION MANUAL

For pipeline distribution, the guidelines for conducting successful operation is necessary. Therefore, it is recommended that operational manual should be prepared. It shall include the guidelines for operation system layouts, precautionary measures,the responsibility of operation staff, instructions for various emergency procedures.

7.4.1 Water Users' Association

The pipeline distribution schemes are being constructed for small and marginal farmers. In order that the beneficiaries can have the freedom in choosing the crops to suit their needs and financial capacities, and for better participation of the farmers, the schemes are to be handed over to the beneficiaries on formation of Water Users Association. The maintenance and management of the scheme will be then carried out by these associations. The most important benefit that is expected to accrue from this arrangement is that the farmers will develop an affinity for and a sense of responsibility towards the scheme and prevent it from misuse and damage. It will also reduce Government intervention. It will also ensure strict observation of Rotational Water Supply (RWS).

7.4.2 Operating Concrete Irrigation Pipelines

The design in the construction of concrete pipe irrigation lines is based on the assumption that lines will be properly operated. An irrigation system, like any other item, can give good service only when properly operated and maintained. Sand, and other suspended matter should not be permitted to settle and remain in a pipeline. This especially applies to the low points where such material naturally accumulates. Besides reducing the capacity of the pipeline, castrictions place an abnormal stress on the line. In filling a pipe line where water is standing in the low points, extreme care must be exercised to avoid excessive pressure due to trapped air. To avoid sudden application of excessive pressures, the pipeline must be filled gradually. Also, this permits the pipeline to adjust to temperature changes. Gates and valves should be kept closed in order to prevent excessive rusting and pitting of seals.

7.4.3 Problems and Precautions

Generally, most concrete pipeline systems will operate without any trouble. But there are always a few failures, generally of the following types:

i. Development of longitudinal cracks in the pipe, principally in the top or in both top and bottom.
ii. Telescoping of sections.
iii. Pipes pushed into the stands.
iv. Development of circumferential cracks.
v. Surging or intermittent flow of water.

The first four types of failures are closely related. The cause of most failures (types, i, ii & iii), and the prevention of some (type iv) stem from the fact that concrete expands when wet, and contracts when dry. Concrete also is affected by temperature, it expands when heated and contracts when cooled. Circumferential cracks are caused by a drop in the water or soil temperatures or by drying out of the pipe. Such cracks may be partially prevented by prestressing the pipe longitudinally. The axial stress set up in pipe by the natural restraint of longitudinal expansions is a partial cause of longitudinal ripping, and also the cause of telescoping and of pipes pushed into structures. The longitudinal rips normally occur within a few days to a week after the pipe is laid. Failure from the above causes can be avoided by proper laying procedure.

If no compromises are made on quality of pipeline and quality of joint, no pipeline shall leak. Pipeline leaks only when there is a significant human negligence, in respect of construction and operation. Some of the precautions are :

i) Use moist soil for the initial backfill after laying the pipe.

ii) Minimize air circulation through a line when laying pipe and when line is not in use.

iii) Avoid laying pipe in extremely hot, extremely cold or in wet weather.

iv) Moreover when pipelines leak, the leaking water appears on the ground as a wet patch almost immediately and can be repaired easily. Regular inspection to attend to such eventualities is necessary.

v) In general, structured network system is much more useful and convenient for the operation.

vi) Distribution chambers to be cleared for silt/debris seasonally.

vii) Ball to be inserted for the silt clearance

viii) Valve/outlet to be provided at the lowest level of the system to facilitate flushing.

ix) Periodical flushing of the system is necessary.

Surges in pipelines (type v) is one of the common disadvantages of an open type system with overflow stands. Air becomes entrained in the water as it over pours the lip into the down-stream portion of the overflow stand. This intimate mixture of air and water is carried down into the reach of pipe downstream from the stand and because of the turbulence of the flow, the tendency for the air to separate out is minimized. Therefore, after a short interval the upstream portion of this reach of water sometimes becomes lighter than the downstream portion causing a reversal of hydraulic gradient, until the water with entrained air flows back to the stand and the air is dissipated. Thus, forward flow is only in cycles. The line functions at only a fraction of its capacity, and the water is difficult to handle. The following observations have been made with regard to surging;

i) Most trouble occurs at low flow because at near capacity flow there is little, if any, fall of water over the baffles.

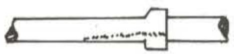
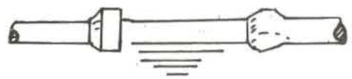
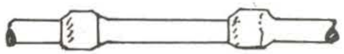
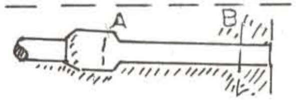
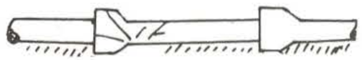
ii) Relief is obtained by placing gate valves in the baffle walls (or between the upstream and downstream portions) of overflow stands and closing these gates only enough to create the pressure necessary for operation of upstream hydrants or laterals.

iii) Relief is also obtained by placing an airtight cover over the overflow stand in question.

Types and causes of rigid pipe fractures and preventive measures to be adopted are highlighted in Table 18.

TYPES AND CAUSES OF REGID PIPE FRACTURES

TABLE - 18

Types of failure	Appearance	Causes	Preventive measures
1. Overload fracture		Excessive vertical load or inadequate bedding	Higher bedding class, or stronger pipe, or concrete surround.
2. Burst socket		Differential thermal or moisture expansion of jointing mortar	Resilient jointing material which does not cause excessive radial pressure on the socket
3. Distrotion fracture		Differential heating or cooling or moisture content	Protection of uncovered pipes against sun of coldnight (or drying wind, with concrete pipes)
4. Beam fracture		Uneven resistance of foundation, or soil movement, or differential settlement.	Flxible joints and uniform hardness of foundation.
5. Pull fractures		Thermal or drying shrinkage of pipe of site concrete, drying shrinkage of clay soil.	Flxible telescopic joints and gaps in site concrete at pipe joint.
6. Shear fractures		Differentaial settlement of wall relative to pipe or/vice versa.	Flxible joints at least at A and D and making AB not more than 3 ft.
7. Bearing fracture		Hard spots in pipe bed.	Elimination of hard spots

Types of failure, 2,4,5 and 6 may accure with regid (e.g. cement mortar) joints. The other failures are uninfluenced by type of joints.

INSPECTORS REPORT- UNDERGROUND PIPING

LOCATION —— ITEM NO ——	UNDERGROUND PIPE SPECIFICATION														
▸															
▸															
WEATHER															
TEMPERATURE															
4 RECEIVING															
5 UNLOADING															
6 STACKING															
7 PRE-EXCAVATION															
LOCATION STAKES															
PIPE STRINGING															
8 EXCAVATION															
TRENCH WIDTH															
SHORING															
DE WATERING															
TRENCH BOTTOM															
EXCAVATED MATERIAL															
9 BEDDING															
MATERIAL															
COMPECTION															
TESTING															
SHORING															
10 PIPE LAYING															
HORZONTAL															
SLOPE															
JOINTS															
11. Q.TY. OF BACKFILL															
MATERAL															
COMPECTION															
TESTING															
SHORING															
12 EXECAVAION BACKFILL															
SECURING PIPE															
13 — AS BUILT DRAWING															
14 TESTING															
REPORT COMPLETED															
FEET INSTALLED															

✓= COMPLETED

A-ACCEPTED R= REJECTED, PR = PORTION REJECTED

Fig. 30 Inspector's Report - Underground Piping

7.5 METHODS FOR FLOW MEASUREMENT

A head loss ranges between 0.5 to 2.5 inches. It will be noted that the plate shown contains slots covered with clear vinyl plastic to permit reading of the head differential from the downstream side of the plate.

These plates have several advantages. They are simple, inexpensive, and easy to install. Furrow streams can be measured with a minimum head differential or restriction to flow, thereby minimizing the increase in the wetted perimeter of the furrow above the measuring point and the probability of overtopping. With reasonable care in setting and reading, the margin of error in the measurements will not exceed 5 percent.

In use, an orifice size is selected so as to produce a head differential within the 0.50 - 2.5 inches range, and the plate is placed in and across the furrow with its top as nearly level as possible. Flow through the orifice must be submerged. In some cases, it may be necessary to restrict the flow downstream from the plate in order to raise the water surface on its downstream side to a level slightly above the top of the orifice. Allowing a few minutes for the head differential to become constant, this differential (the different in the distance from the top of the plate to the water surface on the upstream and downstream sides) is measured with an engineer's scale. Readings are taken to the nearest 0.05 inch.

Flow through the orifice is calculated by the standard orifice formula,

$Q = CA\ V\ 2gh$, which for gallons per minute can be written

$Q = 7.22\ C_d aV\ h$

Where Q = discharge in gallons per minute

C_d = Coefficient of discharge

h = head differential measured in inches

a = area in square inches

V = Velocity

Based on the results of recent calibration studies performed by the Agricultural Research Service, values of C_d in Table 19 and the discharges in Table 20 and 21 were determined.

Table - 19
Average coefficient of discharge for furrow orifices

Orifice diameter (inches)	Value of C_d	
	free flow	submerged flow
3/4	0.61	0.57
1	0.62	0.58
1-3/8	0.64	0.61
1-3/4	0.63	0.61
2	0.62	0.61
2-1/2	0.61	0.60
3	0.60	0.60
3-1/2	0.60	0.60
4	0.60	0.60

7.5.1 WSC Flumes

The WSC measuring flume is in three sizes, which collectively range from 1 to 1,200 gallons per minute. Only the smallest of the three, ranging from 1 to 26 gallons per minute is presented in this chapter. This is the size normally adaptable to the measurement of furrow streams (fig 31).

For larger flumes, the reader is referred to the Washington State College, Washington Agricultural Experiment Station, Station Circular 200, "Measuring Water in Small Channels with the WSC Flume", September, 1952.

The WSC measuring flume developed at the Washington State College adapts the Venturi principle to the measurement of flow in small channels. This flume consists of four principle sections. An entrance section upstream, a converging or contracting section leading to a constricted section or throat, and a diverging or expanding section downstream (fig.31). The bottom of the flume is placed level, both longitudinally and transversely, at a height equal to or slightly higher than the channel bottom. Only one reading on the slanting scale is required. This reading is readily converted to gallons per minute by the use of tables.

Table - 20
Discharges through Submerged Flow Orifices in GPM

Head (inches)	Diameter of Orifice (inches)								
h	3/4	1	1-3/8	1-3/4	2	2½	3	3½	4
0.3	1.00	1.8	3.58	5.80	7.56	11.71	16.80	22.80	29.80
0.4	1.15	2.07	4.14	6.70	8.73	13.52	19.40	26.40	34.60
0.5	1.29	2.32	4.62	7.49	9.76	15.11	21.70	29.50	38.40
0.6	1.41	2.55	5.07	8.20	10.69	16.55	23.70	32.30	42.20
0.7	1.52	2.75	5.47	8.86	11.55	17.88	25.60	34.90	45.60
0.8	1.63	2.94	5.85	9.47	12.34	19.11	27.40	37.20	48.60
0.9	1.73	3.12	6.20	10.05	13.09	20.30	29.10	39.60	51.60
1.0	1.82	3.29	6.54	10.60	13.80	21.40	30.60	41.70	54.50
1.1	1.91	3.45	6.86	11.11	14.48	22.40	32.10	43.70	57.10
1.2	2.00	3.60	7.16	11.60	15.12	23.40	33.60	45.60	59.60
1.3	2.08	3.75	7.46	12.08	15.74	24.30	34.90	47.50	62.00
1.4	2.16	3.89	7.74	12.53	16.33	25.20	36.20	49.20	64.30
1.5	2.23	4.03	8.01	12.97	16.90	26.20	37.50	51.10	66.70
1.6	2.30	4.16	8.27	13.40	17.45	27.00	38.70	52.70	68.80
1.7	2.37	4.29	8.53	13.81	17.99	27.80	39.90	54.30	70.90
1.8	2.44	4.41	8.77	14.21	18.52	28.60	41.10	55.90	72.90
1.9	2.51	4.53	9.02	14.60	19.02	29.40	42.20	57.50	75.00
2.0	2.58	4.65	9.25	14.98	19.52	30.20	43.30	59.00	76.90
2.1	2.64	4.76	9.48	15.35	20.00	30.90	44.40	60.50	78.80
2.2	2.70	4.88	9.70	15.71	20.40	31.70	45.40	61.90	80.70
2.3	2.76	4.99	9.92	16.06	20.90	32.30	46.40	63.30	82.50
2.4	2.82	5.09	10.13	16.41	21.30	33.00	47.40	64.60	84.30
2.5	2.88	5.20	10.14	16.74	21.80	33.60	48.40	65.90	86.00
2.6	2.94	5.30	10.55	17.08	22.20	34.30	49.40	67.20	87.60
2.7	3.00	5.40	10.75	17.40	22.70	35.00	50.30	68.50	89.30
2.8	3.05	5.50	10.94	17.72	23.10	35.70	51.20	69.80	91.00
2.9	3.10	5.60	11.14	18.03	23.50	36.30	52.10	71.00	92.60
3.0	3.15	5.69	11.33	18.34	23.90	37.00	53.00	72.20	94.20
3.1	3.20	5.79	11.52	18.65	24.30	37.60	53.90	73.40	95.70
3.2	3.25	5.88	11.70	18.94	24.70	38.20	54.80	74.60	97.20
3.3	3.30	5.97	11.88	19.24	25.10	38.70	55.60	75.70	98.70
3.4	3.35	6.06	12.06	19.53	25.40	39.30	56.50	76.80	100.10
3.5	3.40	6.15	12.24	19.81	25.80	39.90	57.30	77.80	101.60
3.6	3.45	6.24	12.41	20.10	26.20	40.50	58.10	78.90	103.10
3.7	3.50	6.32	12.58	20.30	26.50	41.10	58.90	80.00	104.60
3.8	3.54	6.41	12.75	20.60	26.90	41.60	59.70	81.10	106.00
3.9	3.59	6.49	12.92	20.90	27.30	42.20	60.50	82.20	107.40
4.0	3.64	6.57	13.08	21.10	27.60	42.70	61.30	83.20	108.70
4.1			13.24	21.40	27.90	43.20	62.00	84.20	110.00
4.2			13.40	21.70	28.30	43.70	62.80	85.30	111.40
4.3			13.56	21.90	28.60	44.20	63.50	86.30	112.70
4.4			13.72	22.20	28.90	44.70	64.20	87.30	114.00
4.5			13.87	22.40	29.30	45.20	65.00	88.30	115.30
4.6			14.03	22.70	29.60	45.70	65.70	89.30	116.60
4.7			14.18	22.90	29.90	46.20	66.40	90.20	117.90
4.8			14.33	23.10	32.20	46.70	67.10	91.10	119.20
4.9			14.48	23.40	30.50	47.20	67.80	92.10	120.40
5.0			14.62	23.60	30.80	47.70	68.50	93.10	121.50

Table - 21
Discharges through Free Flow Orifices in GPM

Head (inches) h	Diameter of Orifice (inches) 3/4	1	1-3/8	1½	1-3/4	2	2½	3	3½	4
0.4	1.24									
0.5	1.39	2.49								
0.6	1.52	2.73								
0.7	1.64	2.94	5.71							
0.8	1.75	3.15	6.11	7.19						
0.9	1.86	3.34	6.48	7.63	10.34					
1.0	1.96	3.52	6.83	8.04	10.90					
1.1	2.06	3.69	7.16	8.43	11.43	14.80				
1.2	2.15	3.86	7.48	8.80	11.94	15.50				
1.3	2.23	4.01	7.78	9.17	12.43	16.10	24.80			
1.4	2.32	4.16	8.08	9.51	12.90	16.70	25.80			
1.5	2.40	4.31	8.36	9.84	13.35	17.30	26.70			
1.6	2.48	4.45	8.63	10.17	13.79	17.90	27.50	38.70		
1.7	2.55	4.59	8.90	10.48	14.21	18.40	28.40	39.90		
1.8	2.63	4.72	9.16	10.78	14.62	19.00	29.20	41.10		
1.9	2.70	4.85	9.41	11.08	15.03	19.50	30.00	42.20	57.50	
2.0	2.77	4.98	9.66	11.37	15.42	20.00	30.80	43.30	59.00	
2.1	2.84	5.10	9.89	11.65	15.80	20.50	31.50	44.40	60.50	
2.2	2.91	5.22	10.13	11.92	16.17	21.00	32.30	45.40	61.90	
2.3	2.97	5.34	10.35	12.19	16.53	21.40	33.00	46.40	63.30	82.50
2.4	3.04	5.45	10.54	12.45	16.89	21.90	33.70	47.40	64.60	84.30
2.5	3.10	5.57	10.79	12.71	17.23	22.30	34.40	48.40	65.90	86.00
2.6	3.16	5.68	11.01	12.96	17.58	22.80	35.10	49.40	67.20	87.60
2.7	3.22	5.79	11.22	13.21	17.91	23.20	35.80	50.30	68.50	89.30
2.8	3.28	5.89	11.42	13.45	18.24	23.70	36.40	51.20	69.80	91.00
2.9	3.34	5.99	11.63	13.69	18.56	24.10	37.10	52.10	71.00	92.60
3.0	3.40	6.09	11.82	13.92	18.88	24.50	37.70	53.00	72.20	94.20
3.1	3.45	6.19	12.02	14.15	19.19	24.90	38.30	53.90	73.40	95.70
3.2	3.50	6.29	12.21	14.38	19.50	25.30	38.90	54.80	74.60	97.20
3.3	3.56	6.39	12.40	14.60	19.88	25.70	39.50	55.60	75.70	98.70
3.4	3.61	6.49	12.59	14.82	20.17	26.10	40.10	56.50	76.80	100.10
3.5	3.67	6.59	12.77	15.04	20.47	26.40	40.70	57.30	77.80	101.60
3.6	3.72	6.68	12.95	15.25	20.75	26.80	41.30	58.10	78.90	103.10
3.7	3.77	6.77	13.13	15.46	21.04	27.20	41.90	58.90	80.00	104.60
3.8	3.82	6.86	13.31	15.67	21.33	27.60	42.40	59.70	81.10	106.00
3.9	3.587	6.95	13.48	15.87	21.61	27.90	43.00	60.50	82.20	107.40
4.0	3.92	7.04	13.65	16.08	21.88	28.30	43.50	61.30	83.20	108.70
4.1			13.82	16.28	22.15	28.60	44.10	62.00	84.20	110.00
4.2			13.99	16.47	22.42	29.00	44.60	62.80	85.30	111.40
4.3			14.16	16.67	22.69	29.30	45.10	63.50	86.30	112.70
4.4			14.32	16.86	22.95	29.70	45.60	64.20	87.30	114.00
4.5			14.48	17.05	23.21	30.00	46.20	65.00	88.30	115.30
4.6			14.64	17.24	23.47	30.30	46.70	65.70	89.30	116.60
4.7			14.80	17.43	23.72	30.70	47.20	66.40	90.20	117.90
4.8			14.96	17.61	23.97	31.00	47.70	67.10	91.10	119.20
4.9			15.11	17.79	24.22	31.30	48.20	67.80	92.10	120.40

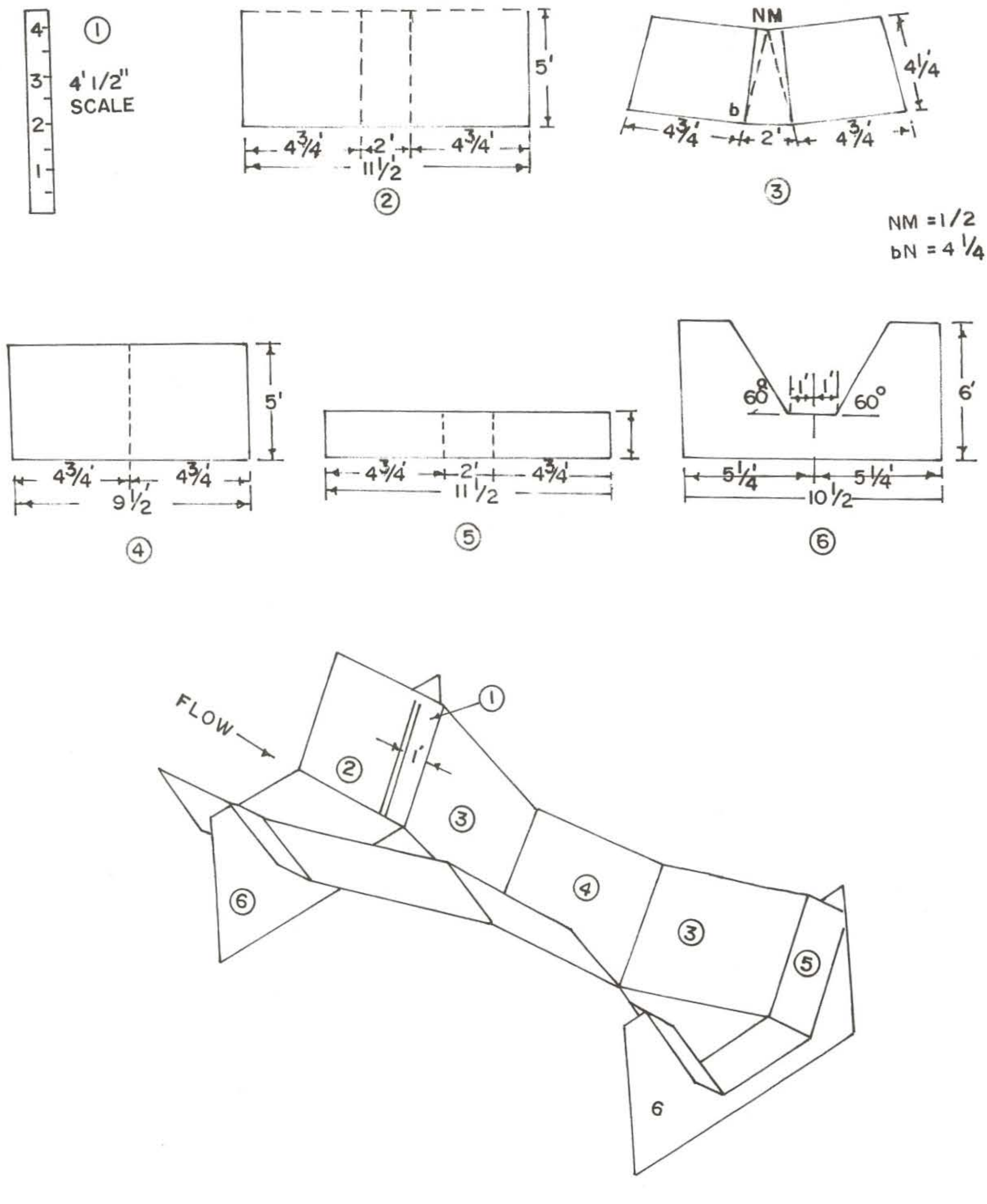


Fig. 31 Components parts of the small WSC flume showing their relative position

The WSC measuring flume has several advantages : Simplicity of construction, low cost, ease of installation, and very low head losses. It is usually made of sheet metal with its component parts are welded together, although the flume can be constructed of wood, concrete, or other materials.

The flume is said to be "operating" when the depth of flow at its downstream end is equal to or less than the depth (Dop) shown in fig.32. If the water surface is at a common level throughout the length of the flume, the flume is said to be "drowned out" and cannot be used in this position. In such cases, the flume is raised slightly until the flow characteristics shown in fig.32 are obtained.

After the slanting scale in the entrance section has been read, table 22 is used to convert the scale reading to flow in gallons per minute.

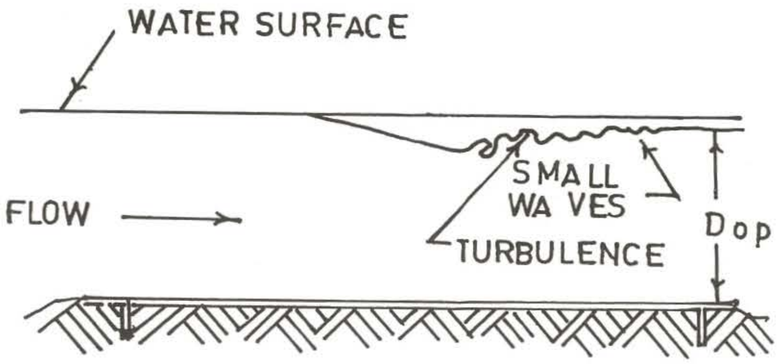


Fig. 32 : Flow Characteristics of the WSC Flume in Operation

Table - 22
Discharge for Small WSC Flume IN Gpm

Scale reading (inches)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1			1.5	1.8	2.2	2.6	3.0	3.5	4.1	4.7
2	5.3	6.1	6.9	7.7	8.6	9.5	10.4	11.5	12.7	13.8
3	15.0	16.4	17.8	19.3	20.8	22.4	24.0	25.8		

7.5.2 Coordinate Methods

In the coordinate method, coordinates of the jet issuing from the end of a pipe are measured. The flow from pipes may be measured whether the pipe is discharging vertically upward, horizontally, or at some angle with the horizontal. Since the discharge pipe can be set in a horizontal position for measurement purposes, there is no need here for a discussion of flow from pipe in an angular position.

Coordinate methods are used to measure the flow from flowing wells (discharging vertically) and from small pumping plants (discharging horizontally). These methods have limited accuracy owing to the difficulty in making accurate measurements of the coordinates of the jet. They should be used only where facilities for making more accurate measurements by other methods are not available and where an error of upto 10 percent is permissible.

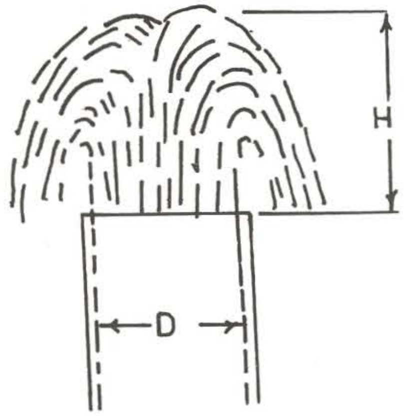


Fig. 33 Required Mesurements to obtain flow from Vertical Pipes

To measure the flow from pipes discharging vertically upward, it is only necessary to measure the inside diameter of the pipe (D) and the height of the jet above the pipe outlet (H) Fig.33. Table 23 gives discharge values for pipe diameter upto 12 inches and jet heights upto 40 inches.

Y (inches)	Size of pipe (nominal diameter)				
	2-inch G.p.m.	3-inch G.p.m.	4-inch G.p.m.	5-inch G.p.m.	6-inch G.p.m.
			WHEN X = 18 INCHES		
1.80	166	346	624	1014	1400
2.40	144	305	557	907	1261
3.00	129	274	503	826	1153
3.60	117	251	462	754	1068
4.20	109	233	431	700	992
4.80	101	220	404	655	934
5.40	95	206	382	615	884
6.00	89	197	364	579	839
6.60	84	187	346	548	799
7.20	81	180	332	521	763
7.80	77	172	319	498	732
8.40	75	166	305	476	705

* Table for standard steel pipe prepared from data resulting from actual experiments conducted at Purdue Univ. and reported in Purdue Engin. Expt. Sta. Bul. 32, "Measurement of Pipe Flow by Coordinate Method," August 1928.

Hand compaction for lateral - I two parallel pipe line

Jointing of Riblock Main Pipe Line at ch. 55m

CHAPTER - 8

RESEARCH AND DEVELOPMENT

8.1 RESEARCH AND DEVELOPMENT IN PIPELINE DISTRIBUTION SYSTEM

There is a scope for research in the avenue of material required for pipe line distribution system. While undertaking material research, following hints shall be taken into account.

1) Research for piping material which will be light in weight and flexible.
2) Excellent joints/Joint material should be discovered which eliminate exfilteration and infilteration from joint area.
3) For better hydraulic condition, it should have smooth surface.
4) To avoid many joints, the pipe material which will facilitate faster installation and having longer length should be discovered.
5) Such pipe could be repaired easily at site itself.

8.2 PIPE LINE RESEARCH AND DEVELOPMENT

Better valves which will eliminate water hammer and regulate discharges without hindering the continuity of flow and having low cost should be developed.

The pressure is varying at various points of pipeline. If some economical device to regulate the pressure is found out, it will be much useful to avoid unequal distribution of water.

The difficulty of variable discharge (instead of constant discharge) through hydrants/turnouts is always encountered along the pipeline, as hydraulic gradient goes on varying along the length, if more than one hydrant/turnout is operated. It is therefore necessary to develop low cast self regulating valve which will deliver nearly constant discharge under variable head.

Various controlling and regulation sensing devices should be found out for automation purpose. Computerised delivery system on the basis of climatological parameters should be evolved.

Various flow measuring devices for velocity discharge, pressure and head should be evolved.

Sophisticated water meters for discharge measurement should be manufactured/invented.

At present large number of chemicals are being used in the form of helpset, glues, fabrics, chemicals, solution, softner, etc. There is vast scope to enlarge list of chemicals and also to make the chemicals more economical and efficient for leak proof joints.

Popularisation of RIBLOC pipe must be developed.

Possibility of all minor irrigation projects with the pipe distributary system should be explored.

The Government and different agencies involved may have to bring the cost of the pipe distribution system still lower for widespread use in poor agrarian community of the state.

The financial viability and economics of the pipe distribution system has to be evaluated particularly with reference to the Government investments therein.

The pipe distribution system has many mechanical devices and as such social acceptability of the system particularly to keep in working condition has to be evaluated.

The distribution of water through the closed pipeline would prevent the seepages and thus would also affect the recharging of groundwater. This also needs to be considered to what extent the advantages of recharging is being lost. The efficacy of system should be checked for variation in the cropping pattern by carrying out sensitivity analysis.

8.3 USE OF COMPUTER IN PLANNING AND DESIGN OF PIPE DISTRIBUTION SYSTEM

In order to optimise the sizes of pipes and network planning,suitable softwares shall be developed. Such computer programming should be utilised for determining the variables, such as pipe size, hydraulic gradient, losses, head losses, elevators etc. Suitable operation method which will last longer and give maximum benefits shall be found out for changing demands.

Software like CYVERNET - from "Haestad Methods" can be easily modified for design/planning/operation of the pipeline distribution system for irrigation.

CHAPTER - 9

EXPERIENCES AND CASE STUDIES

The pipe distribution system has developed in a rapid way in the last 15-20 years in water management especially in conveyance system clubbed with sprinkler and drip irrigation for the crop. It is possible to expand irrigation facilities to at least double the area with the same quantity of water. The conveyance of water through pipes by using pressurised irrigation method is common in USA, Israel, Australia, etc. The thinking process in this direction has already started in the States of Gujarat, Maharashtra and Madhya Pradesh. Maharashtra Government has decided to give sanction for many lift irrigation schemes only, if the water is conveyed through pipes and used by drip and sprinkler methods of irrigation. The Gujarat Government is planning to bring large areas under irrigation by introducing drip method in the Narmada Project. Madhya Pradesh has also introduced pipe distribution system in number of medium and minor projects under USAID assisted Programme. In the following paras experiences and case studies are mentioned in respect of some of these projects.

9.1 BURIED PIPE IRRIGATION SYSTEM - A CASE STUDY OF PUNADE AND WAVA MINOR IRRIGATION SCHEMES IN KONKAN REGION:

These two projects are taken under USAID assistance as pilot projects. The pipe distribution system (Buried Pipe Irrigation System) for Wava and Punade have been completed recently. The cost per ha.for Wava and Punade for Pipe distribution system works to Rs.32,800/- and Rs.28,800/- respectively for D.S.R. of 1990-91. Details of the project are given in the following paras :

9.1.1 Salient Features of Punade M.I.Scheme

This Punade Minor Irrigation Scheme comprises of earth dam across nalla near village Punade in Uran Taluka, District Raigad. The salient details of the Scheme are given in Table 25.

Table - 25
Salient Features
Punade M.I.S., Taluka Uran, Distt. Raigad

1.	**General**		
	i)	Catchment area upto dam site	- 1.14 km^2
	ii)	Gross command area	- 202 ha
	iii)	Culturable Command Area	- 109 ha
	iv)	Irrigable Command Area	- 105 ha
	v)	Area Under Submergence	- 19.20 ha
	vi)	Submergence ratio	- 18.28%
2.	**Hydrology**		
	a)	**Rainfall**	
	i)	Raingauge Station considered	- Pen
	ii)	50% dependable rainfall	- 2889 mm
	iii)	Average annual rainfall (20 years)	- 2836.52mm
	b)	**Yield**	
	i)	50% dependable yield	- 2.452 Mm^3
	c)	**Storage**	
	i)	Gross storage	-1.717 Mm^3
	ii)	Dead storage	- 0.011 Mm^3
	iii)	Live storage	-1.706 Mm^3
	iv)	Gross annual utilisation	- 1.52554 Mm^3
3.	**Earthen Dam**		
	i)	Top elevation R.L.	- 126.00 m
	ii)	Length	- 302 m
	iii)	Maximum height	- 29.01 m
	iv)	F.R.L.	- 123.00 m
	v)	Free board	- 1.50 m
	vi)	M.W.L.	- 124.50 m
4.	**Masonry spillway**		
	i)	Maximum flood discharge	-41.35 cumecs
	ii)	Design flood	- 41.35 cumecs
	iii)	Type of spillway	- Clear over fall
	iv)	Length	- 12.40 m
	v)	Design Flood Lift	- 1.50 m
5.	**Canal**		
	i)	Head regulator sill level	- 102.50 m
	ii)	Discharge at head	- 0.290 cumec
	iii)	Length of main canal	- R.B.C.-Open canal 0 to 290 M& under ground pipe system 290 to 1740 m

iv)	No. of Cross Drainage Works - Open Canal		- 8 Nos.
v)	No. of measuring devices		- 1 No.

6. Irrigation

i) Crop pattern

a) Kharif	- 65%	- Paddy	65%
b) Rabi Crops	- 100%	- Groundnut	25%
		Vegetables	25%
		Paddy	40%
		S.T.Rice	10%
			100%

ii)	Intensity of irrigation	-	96.33%
iii)	Field application efficiency	- Kharif	80%
		Rabi	75%
iv)	Over all efficiency	- Kharif	53%
		- Rabi	50%
v)	Cost of project	- 10.89 Million Rupees (A.S.R.)	
vi)	Cost per Mcft.of gross storage	- Rs 0.1518 Million	
vii)	Cost per Hect. of I.C.A.	- Rs 0.0715 Million	
viii)	Economic rate of return	- 12.315%	
ix)	Remarks regarding economic feasibility of project	- The project being in Konkan area the ERR is required to be more than10%. Hence the project is feasible.	

9.1.2 General Layout Planning

9.1.2.1 Layout Planning of Main Line of the Buried Pipe Irrigation System :

The Command Plan reveals a level difference of 21 metre in irrigation outlet sill EL and average field level in command area. Since the PVC Pipes of required diameter can not take this pressure of 21 metre 4 fall structures are provided in the initial reach of canal to dissipate about 12 metre of head and then an Intake Chamber is provided from where the main pipe line starts. Thus this is a semi-closed buried pipe system. The main pipe is aligned in such way that with minimum length, maximum command area is covered. The main pipe line is taken along the whatever ground profile is met with, and buried underground with a minimum cover of 85 cm to 90 cm. The unplasticised Ribbed PVC pipes (i.e. Riblock pipes) are used for main pipe lines. These Ribloc Pipes are light weight, easy to handle, easy to fix and joint and quite leakproof.

The trench excavation is done as per usual methods and pipes are jointed using coupler strips and glues. The minimum setting time of these glue-joints is 12 hours or so and there shall not be any wet surface. Where ground water table is high, then already jointed and well set pipes can be taken to the trench site and just lowered and by adequate dewatering the minimum number of joint can be tackled. These PVC ribbed pipes are low pressure pipes with limiting pressure of 1 Kg/cm^2 i.e. only upto 10 m. water head. Also the minimum driving head over the main pipe line at intake chamber shall be 1.2 m. The average velocity of flow shall be near about 1m per sec. (Varying 0.8 m. per sec. to 1.2 m. per sec.)

9.1.2.2 Layout Planning of Laterals and Chaks

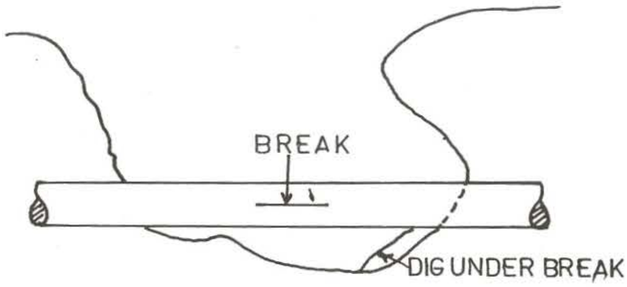
Similar to main pipe, the laterals are aligned in such a way that they cover maximum area in minimum length. The chak size selected is approximately 10 ha. and one lateral shall irrigate approximately 10 ha. area. Looking to the topography and location, the sub lateral (Branches) are aligned so as to cover entire command area. In this scheme there are 12 laterals and 12 chaks covering total irrigation command area of 136 ha. The laterals are also of Ribloc pipes upto 150 mm dia and then usual PVC pipes of 110 mm and 90 mm dia are used. Also at the tail end drain pipes (PVC pipes) are used to drain out water in case of repair works.

9.1.2.3 Layout Planning of Hydrants

In this Buried Pipe Irrigation (BPI) System, the ultimate point of delivery of water is a hydrant which supplies water to the fields. The Hydrants are located in such a way that they are at the highest elevation of the field to be irrigated and field area is limited to 1 ha. only. Thus a single hydrant supplies water to approx 1 ha. area. As land holdings are very very small (Average size is 0.17 ha/person) a universal Hydrant (Fig. 37) which can rotate in 360° (i.e. all around) is fixed on laterals with discharging capacity of 10 LPS. From this hydrant the small length field channels are to be constructed by individual farmer upto their fields.

STEPS

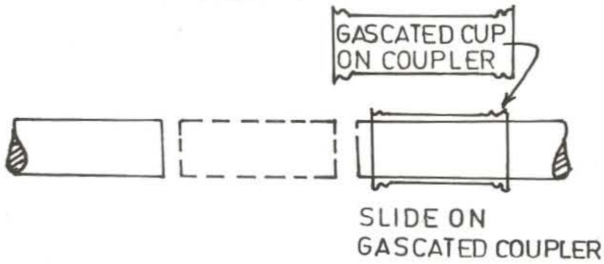
1. Open up Trench
2. Dig under Break
3. Cut out and Break



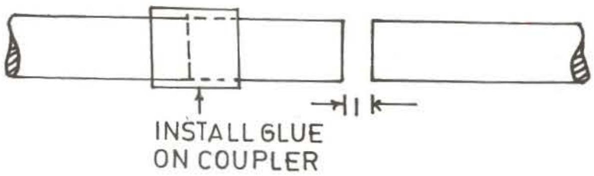
4. Clean all mud from pipe
5. Slip repair coupler over pipe

6. Cut a repair Pipe 1" Short

7. Glue on coupler to repair pipe and pipe Trench (Set up 15mm)



8. Slide Gasketed Repair coupler over 1" opening and counter.



9. Test for Leaks.

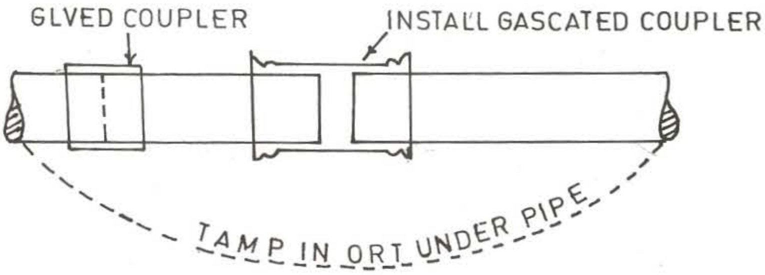
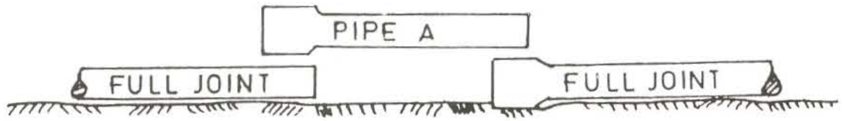


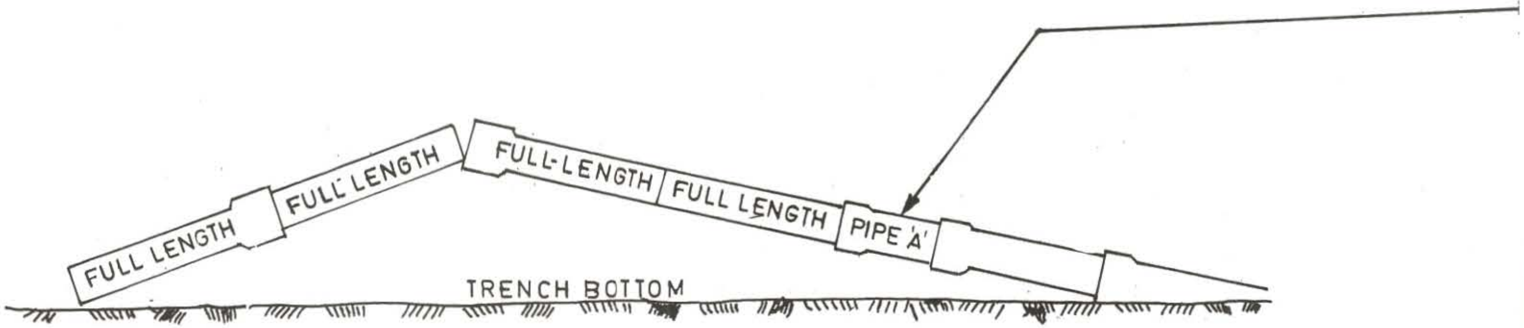
Fig. 35 Repair P.V.C. Pipe in the Trench with Both Ends Fixed

How to Coupple Two Pipes Together when the Trench is open on both ends.



1. Measure very Accurately the necessary length of Pipe white laying on Flat Ground

Install Solvent of Gloe The Short Pieces of Pipe cut to length at least 2 Joints up stream.



A) Apply Solvent & Glue to both bell and spigot in the usual manner.

B) Lift in air as shown, connect Line up and Lower the Pipes together into the Trench. The Gloe most still be wet you only have about 30 Sec to 40 seconds to do this hurry up.

If is always preferable to start at one end on the other to avoid this coupling.

Fig. 36 Two Pipes together when the Trench is open on both ends.

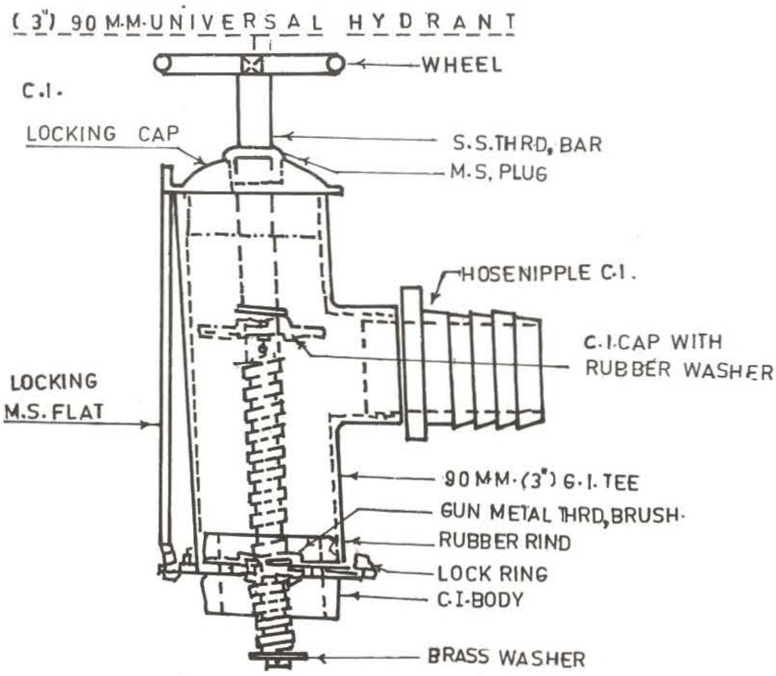


Fig. 37 Universal Hydrant

Universal Hydrants are designed in a manner to provide water to all surrounding field by mounting on a PVC male threaded adopter. It has locking arrangement to avoid misuse and keeping in required direction.

It consists of cast iron body, locking cap, inner cap and moving square threaded Stainless steell rod with Gun metal bush, GI.

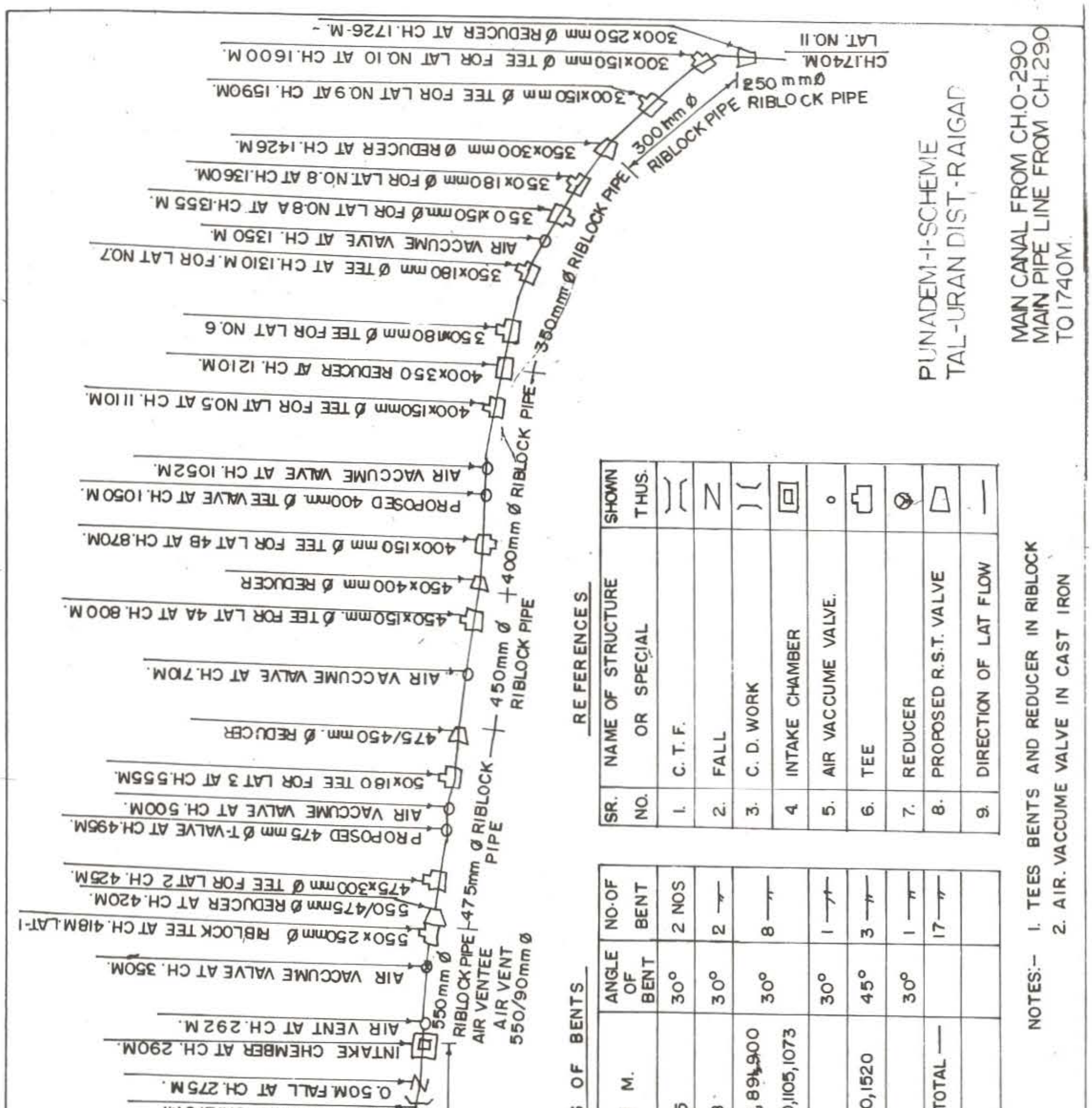
Tee and CI Hose Nipple and MS plug at the top.

Hydrants are tested as specially made arrangement, at working pressure 5 kg/cm^2.

9.1.2.4 Layout Planning of Valves/Bends, Float Valves

In layout planning of valves etc. the following principles are adopted.

1) There shall be sluice valve and float valve in the initial reach of each lateral.
2) There shall be air relief valve at all highest point of main pipe as well as laterals. There shall be drain valve at lowest level on bends in elevation for main pipe line.
3) There shall be anchor block of P.C.C. at every bend in plan of main pipe/laterals to take care of thrust etc.



DETAILS OF BENTS

DIMETER OF PIPE	CH. IN M.	ANGLE OF BENT	NO. OF BENT
550 mm. Ø	336, 365	30°	2 NOS
450 mm Ø	720, 798	30°	2 —/—
400 mm Ø	850, 866, 891, 900 1000, 1090, 1105, 1073	30°	8 —/—
350 mm Ø	348	30°	1 —/—
300 mm Ø	1450, 1490, 1520	45°	3 —/—
250 mm Ø	1728	30°	1 —/—
	TOTAL —		17 —/—

REFERENCES

SR. NO.	NAME OF STRUCTURE OR SPECIAL	SHOWN THUS.
1.	C. T. F.	
2.	FALL	
3.	C. D. WORK	
4	INTAKE CHAMBER	
5.	AIR VACCUME VALVE.	
6.	TEE	
7.	REDUCER	
8.	PROPOSED R.S.T. VALVE	
9.	DIRECTION OF LAT FLOW	

Fig. 38 Punade M.I. Scheme Ch. 290 to 1740 M.

9.1.3 Hydraulic Design of Buried Pipe Irrigation System

9.1.3.1 Design of Main Pipeline

The cropping pattern proposed for this project and the maximum crop water requirement as per Modified Penman method are as below :

The crop water requirement during second fortnight of March is maximum and considered for design purpose. The net Crop Water requirement which is calculated by Modified Penman Method, for 1 ha. adopting cropping patterns prescribed by Deputy Director of Agriculture, Konkan Region, Thane is as follows :

Sl. No.	Name of Crop	Percentage	Area under crop in ha	Water requirement in ha mm for IInd fortnight of March i.e. Max. NIR	Total water requirement in ha. mm	Remarks
1.	Rabi Paddy	40%	0.40	135.00	54.00	
2.	Rabi Groundnut	25%	0.25	104.07	26.02	
3.	Rabi Vegetables	25%	0.25	—	—	Base period of these crop are completed before IInd fortnight of March water requirement is Nil.
4.	S.T. Rice	10%	0.10	—	—	
	Total	100%	1.00		80.02	

Considering field application efficiency as 75% and capacity factor 1.05, flow period 12 days with 14 hrs/day, discharge required to irrigate 1 ha area in lps is

$$= \frac{80.2 \times 100 \times 100 \times 1000}{1000 \times 12 \times 14 \times 60 \times 60 \times 0.75} \times 1.05$$

$$= 1.852 \text{ lit./sec.}$$

Say 1.85 lit./sec./ha

Thus,the water allowance worked out is 1.85 lps/ha for 12 days Rotation and day is taken as 14 hours. From these calculations the design discharge works out to 290 lps for entire are 140 ha.

The diameter of Main pipe for the designed discharge of 290 lps is worked out using the Nomograph of the Ribloc PVC pipes supplied by the Manufacturer. On knowing the required discharge of 290 lps and assuming velocity of flow as 1.3 m/sec(higher than average velocity of 1.0 m/sec.) at the initial reach, the diameter works out to 550 mm with the friction loss given as 0.20 m/100 m length. Similarly the diameter of each zone of the main pipe is worked out. The maximum velocity is limited to 1.3 m/sec. and the minimum being 0.6 m/sec. The maximum dia of main pipe is 550 mm at head and at the tailend, the diameter of main pipe is 250mm.

9.1.3.2 Hydraulic Design of Laterals

From the water allowance of 1.85 lps/ha, the discharge required for each lateral is calculated as area on each lateral is known. Here it is assumed that all laterals to run simultaneously and each hydrants will deliver at 10 lps for 15 hours in every 7 days interval. This criteria reduces the pipe diameters in turn cost is reduced and also the available head is fully utilised by particular operation schedule (i.e. rostering of Hydrant). The Hydrants to be operated from tail to head in sequence of predetermined group of two or more at a time. This design concept optimises the cost of the system. If the day time running of 14 hours per day considered, each hydrants shall be open for 2.22 days with day considered as 14 hours only as night irrigation is not much in vogue, in Konkan Region. The minimum driving head at any hydrant shall be 30 cm. A typical operation schedule of lateral 7 is given in Table 30. This shows that all the irrigation is completed in 12 days rotation and there is almost no idle time of pipes running.

9.1.4 Construction of Buried Pipe Irrigation System

9.1.4.1 Excavation for Main Pipeline :

The trench width for main pipe is kept as pipe dia plus 30 cm. The minimum cover is 75 to 90 cm. Since the pipe line passes near by House/Habitation, controlled blasting was done in such area. Wherever hard rock is met on the ground surface itself the excavation is done to burry the pipe and P.C.C. capping is done on top of these pipes. The pipes shall be at least 60 cm. below the Hydraulic Gradient Line (H.G.L.) at that point.

9.1.4.2 Excavation for Laterals

The excavation for laterals is carried on same line as for main pipe line. Since most of laterals pass through paddy field, cover of 60 to 75 cm is fully ensured. To reduce construction time, P.C.C. capping on top of pipe is done in Hard Rock Patches.

9.1.4.3 Refilling of Trenches

Whenever pipes are laid as per required level, refilling on top of pipes and on sides are done immediately after setting of pipe joints. The refilling is done with selected materials and well watered and compacted. As the pipes being light-weight, well compacted earth filling on top is necessary to avoid floating of pipes due to seeping of water around pipes.

9.1.4.4 Fixing of Air Valves/Float Valves, Sluice Valves etc.

The location of the valves are already determined as explained in para 3.7. The construction for sluice valve and float valve chambers is done at the required locations. The sluice valve/floats valve controls the flow in each lateral. Generally CI sluice valves are used but for this scheme PVC Sluice valves were designed and used for the PVC pipes.

9.1.5 Testing of Buried Pipe Irrigation System

After completion of the pipe laying, refilling the trenches, fixing of valves etc., the system is ready to receive water. In July, 1992 the pipe line was tested for a discharge of 220 lps against full discharge of 290 lps (As the laterals were not completed). The hydrants were operated to deliver the discharge to the fields. It was noticed that the hydrants delivered approx 8.5 lps discharge against designed discharge of 10 lps. The less discharge was mainly due to leakage at air valves, sluice valves. When these leagakes are fully plugged, the hydrants shall deliver the full discharge of 10 lps. But it was noticed that all hydrants received water and there was no patch of land where water did not reach. Also the Ribloc pipes were found to be leak-proof and quite useful in irrigation system. These Ribloc pipes were used probably for the first time in India in Buried pipe Irrigation System by a Government Department.

9.1.6 Conclusion

The total cost of this buried pipe irrigation system was Rs 28,800/- ha. The Ribloc Pipes are quite easy to handle, joints are quite leak-proof and deliver the designed discharges. This system is quite cost effective. The initial cost is a bit high but there are almost no maintenance costs. Incidently, the system is simple and pipe laying is quite fast. The entire construction work was done in about four months time only. This type of Buried Pipe Irrigation is very useful in hilly and remote areas like in Konkan Region.

9.2 E.E.C.PROJECT IN KONKAN REGION.

In Konkan Region, number of completed Minor Irrigation Schemes are proposed to be converted for Pipe Distribution System under E.E.C. Assistance. The list of the Schemes and area proposed under each scheme are furnished in Table 26. Details about the existing irrigation projects and proposed buried pipe irrigation system for modernisation of canal systems in Konkan region are given below:

9.2.1 Topography

The Konkan Region comprises of 4 districts namely Thane, Raigad, Ratnagiri and Sindhudurga. This Konkan Region covers area of 3.01 million ha. along the west coast of India. The configuration of this region is typical one which has a narrow strip of land (approx width is 50 km) sand-witched between the Arabian Sea and Sahayadri Hills. The rivers originate at Sahayadri Hills and flow westwards with flood water during monsoon but almost dry during fair weather season. The entire region falls under heavy rainfall zone, having annual rainfall of 2200 mm, mostly from June to September.

9.2.2 Existing Irrigation Project

In Konkan Region, during Kharif and Konkan Hangam conventional paddy is grown. Paddy being non-remunerative crop with field to field irrigation, general economic condition of the farmers remained static and there is no up-lift of living standard inspite of availability of irrigation facility to about 40,000 ha area. Due to heavy monsoon and contour canal running along foot of the hills with falling contour, heavy siltation occurs every year. The weed growth is also tremendous resulting in heavy expenditure on maintenance and repairs of the canal system.

9.2.3 Deficiencies in Existing System

As mentioned above, the field to field irrigation system practicised in Konkan Region does not allow the farmers to take different crops and thus crop diversification is not possible with this system. Besides this, there are heavy seepage losses due to pervious nature of soils in Konkan Region which ultimately results in heavy water losses in conveyance system and as such there is a wide gap between the potential created and actual area irrigated.

9.2.4 Need for Modernisation of Canal System

As explained above, there are heavy losses in conveyance system, resulting in less irrigation than projected and heavy expenses on maintenance and repairing of the system every year. Besides this, crop diversification is not possible in field to field irrigation system. These are the factors which indicate need for modernisation of the canal system in Konkan Region.

Table - 26
Details of Few Projects Taken Under E.E.C.

Sl. No.	Name of Scheme	Irrigation Potential Ha.	Cost of pipe distribution system Rs in lakhs	Cost per hect.of system Rs (89-90 DSR)
Distt.	**Raigad**			
1.	Ambeghar	124	38.32	30903
2.	Unhere	131	29.95	22882
3.	Dhokshet	138	42.17	31007
4.	Pabhare	133	41.20	30977
5.	Kalote Mokashi	103	42.50	41262
6.	Donvat	122	34.94	28839
7.	Kal Project Mangaon Branch Minor No.10	351	100.35	28500
8.	Morba Branch Minor No.4	158	47.52	30482

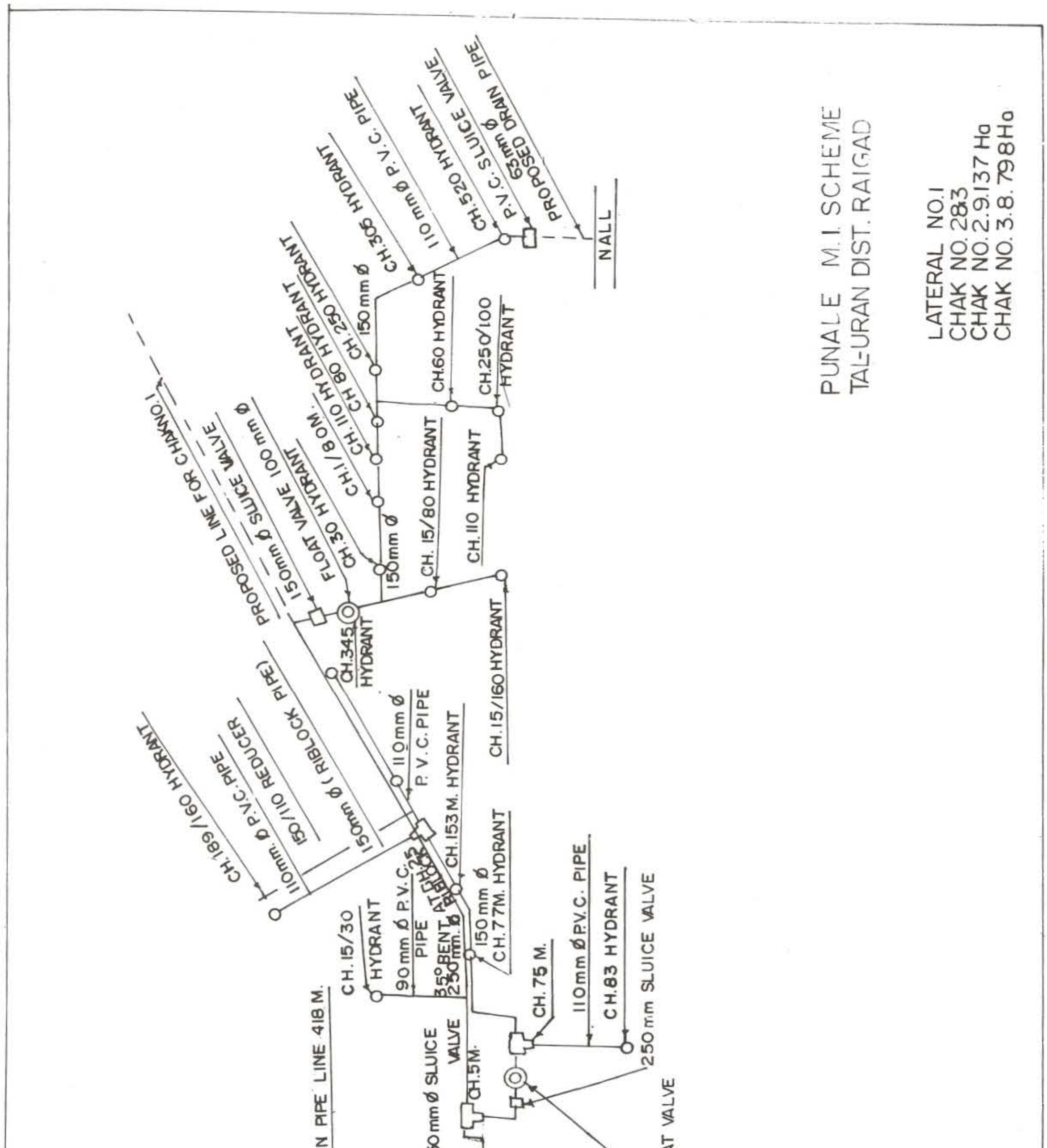


Fig. 39 Punade M.I.Scheme - Lateral No.1

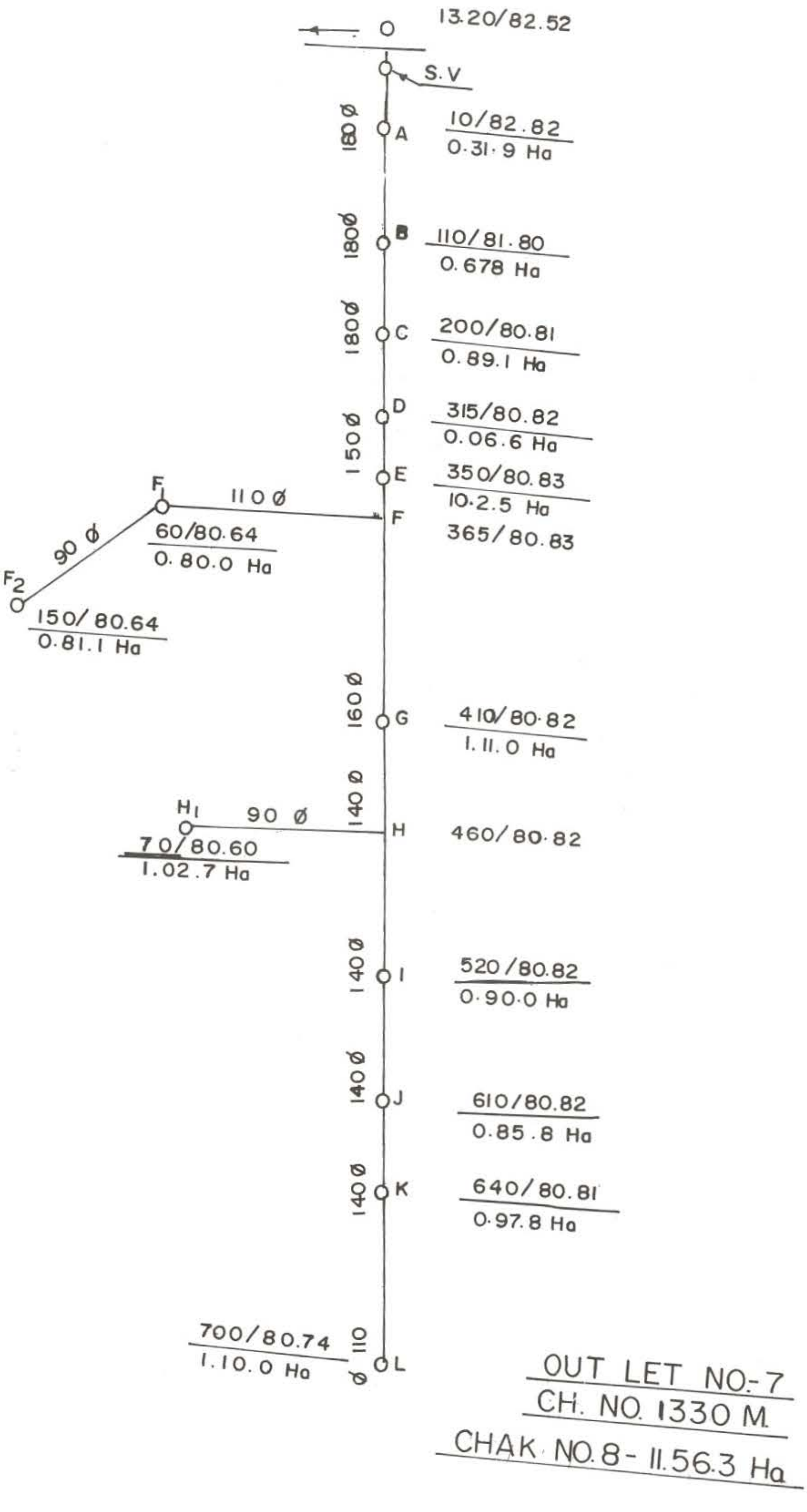


Fig. 40 Punade M.I.Scheme - Outlet No.7

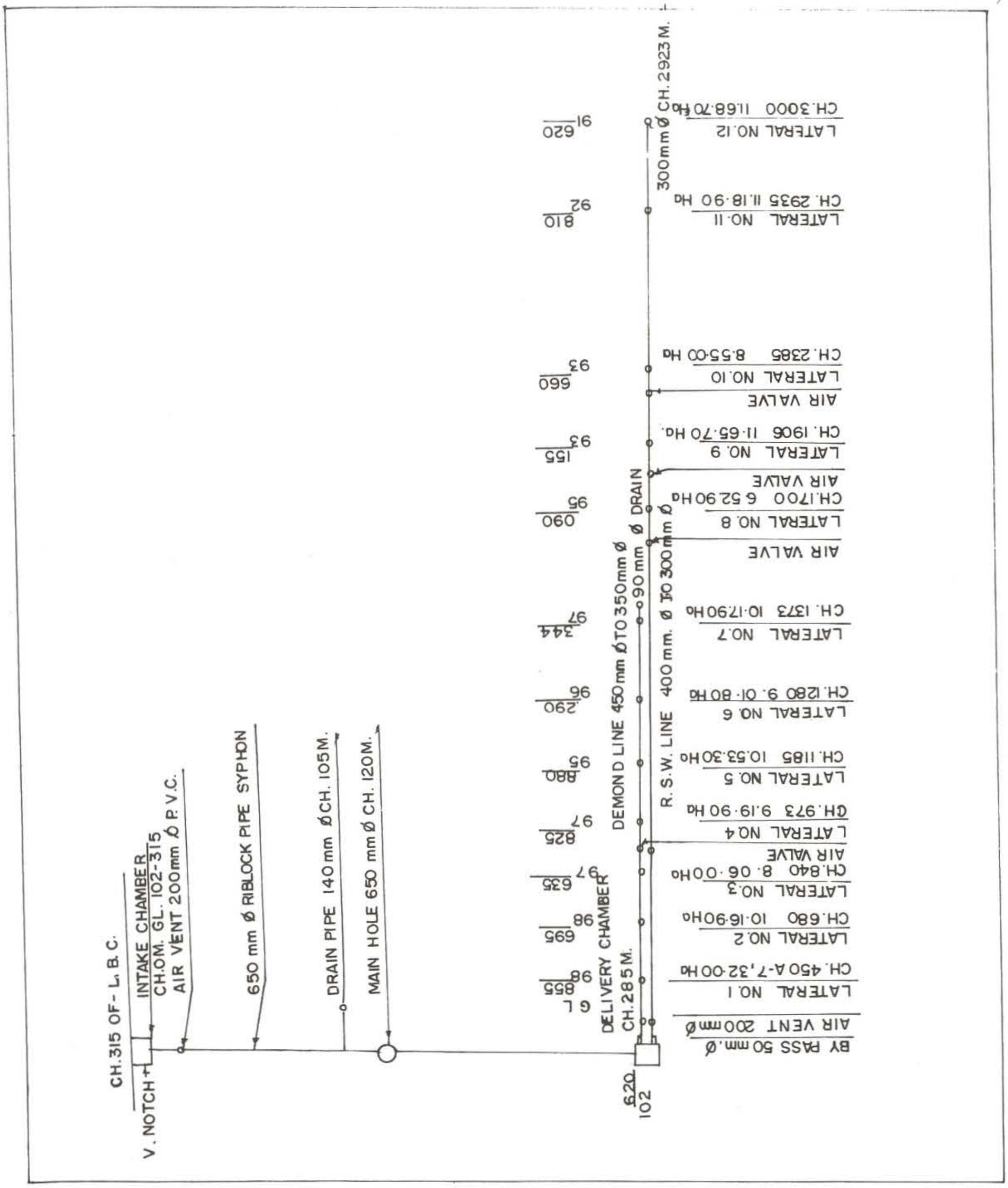


Fig. 41 Main pipe line of Wawa M.I.Scheme

TABLE - 27
DESIGN STATEMENT

Punade M.I.Scheme Tal. Uran. Dist. Raigad

Main Pipeline (Riblock)

H.G.L = C.B.L. + FSD - losses due to intake chember

H.G.L. = 90.18 + 0.45 - 0.10 = 90.53

OUTLET NO.	CH. IN.m.	LENGTH IN M. ACTUAL	ADDI-TIONAL	TOTAL	AREA IN HEC. AT POINT	CUMULA-TIVE AREA	DIS. REQUIRED AT EACH OUTLET	IN LPS CUMU LATIVE	DIA-METER OF PIPE	FRIC. LOSSES mm/100 m	IN BET OUTLET	H.G.L.	PIPE INVERT LEVELS	HEAD IN m.	VELOCITY IN m/sec	REMARKS
INTAKE CHAMBER	200											90.53	89.00	1.53		
OL-1	420	220	20	240	27.796	140.000	60	290	550	0.20	0.48	90.05	85.87	4.18	1.30	
OL-2	430	10	10	20	18.428	112.204	40	230	475	0.22	0.04	90.01	85.90	4.11	1.30	Proposed for future' expansion
OL-3	560	130	10	140	11.275	13.776	20	190	475	0.14	0.20	89.81	84.36	5.45	1.00	
OL-4A	840	280	20	300	10.623	82.901	20	170	450	0.20	0.60	89.21	84.68	4.53	1.15	
OL-4B	855	15	10	25	2.865	71.878	10	150	450	0.16	0.04	89.17	84.69	4.88	1.00	
OL-5	1120	265	30	295	9.600	69.013	20	140	400	0.22	0.65	88.52	81.89	6.63	1.15	
OL-6	1190	70	20	90	11.077	59.413	20	120	350	0.32	0.29	88.23	81.58	6.65	1.25	
OL-7	1320	130	20	150	11.563	48.336	20	100	350	0.22	0.33	87.90	81.85	6.95	1.10	
OL-8	1330	10	10	20	12.008	36.773	20	80	350	0.14	0.03	87.87	81.85	6.02	0.85	
OL-9	1540	210	20	230	9.367	24.770	20	60	300	0.20	0.46	87.41	80.71	6.70	0.87	
OL-10	1590	50	20	70	6.383	15.383	20	40	250	0.22	0.15	87.26	80.87	6.39	0.82	
OL-11	1600	10	10	20	27.428	9.000	20	20	200	0.18	0.04	87.22	80.15	7.07	0.62	Proposed for future expansion

1) Losses in Specials are assumed to be equivalent to losses in 10M length of Pipe.
2) Frictional losses are worked out from Nomogram Which is based on Colobrook formula.
3) Difference in initial H.G.L. and tail and Pipe invert level = 10.38M.
4) Total Head loss due to friction - 3.31M.
5) Maximum Head created at OL-11 - 6.99M.
6) Minimum Head at point OL-2 (=Ch.430) = 4.11M.
7) Design Pressure as per diameter of pipe as following

Diameter of Pipe	550 dia (125 vx)	475 dia (125vx)	450 dia (125vx)	400 dia (125 vx)	350 dia (125 vx)	300 dia (110 vx)	250 dia (110 vx)	200 dia (110vx)
Design Pressure	1.87 kg/cm^2	1.06 kg/cm^2	1.06 kg/cm^2	1.19 kg/cm^2	1.36 kg/cm^2	1.44 kg/cm^2	1.72 kg/cm^2	2.14 kg/cm^2

TABLE - 28
DESIGN STATEMENT

Punade M.I.Scheme Tal. Uran. Dist. Raigad
Outlet No. 7 At CH 1320 M for Chak No. 8
H.G.L. 87.90

POINTS	CH. IN m	LENGTH IN METER ACTU-AL	ADDI-TIONAL	TOTAL	AREA IN HEC. AT A POINT	CUMULAT-IVE	DISCHARGE IN lps REQUIR-ED IN 12 DAYS AT RATE OF 1.85LPS/ha.	PROVID-ED AS PER SCHE-DULING	DIAMETER OF PIPE IN mm	FRICTIONAL LOSSES IN mm IN METER /1000M	TOTAL IN BETWEEN POINTS	H.G.L.	G.L.	HEAD	VELOCITY IN m/sec	RE-MARK
O	0											87.90				
OA	10	10	20	30	0.319	11.563	21.39	30/20	180	8.00/3.30	0.24/ 0.11/0.03	87.66/67.79	82.820	4.84	1.30/0.85	
B	110	100	10	110	0.678	11.244	20.80	30/20	180	8.00/3.30	8.88/0.42	86.78/86.37	81.89	4.89	1.30/0.45	
C	200	90	10	100	0.891	10.566	19.55	30/30	180	8.00/3.80	0.80/0.38	85.98/86.99	80.870	5.11	1.30/0.85	
D	315	115	10	125	1.066	9.675	17.89	30/20	160	7.00	0.87	85.11/86.12	80.820	4.29	1.10	
E	350	35	10	45	1.025	8.609	16.00	30/10	160	7.00/1.90	0.32/0.68	94.79/85.80	80.830	3.96	1.10	
F	365	15	10	25	1.611	7.584	14.03	20/20	160	7.00	0.17	85.63	80.830	4.80	1.10	
G	410	45	10	55	1.110	5.973	11.05	20/20	160	7.00	0.39	85.24	80.820	4.42	1.10	
H	460	50	10	60	1.027	4.063	9.00	20/20	140	13.00/3.60	0.78/0.22	84.46	80.51	3.95	1.10/0.70	
J	520	60	10	70	0.900	3.836	7.10	20/20	140	13.00	0.91	83.55	80.820	2.73	1.40	
K	610	90	10	100	0.858	2.936	5.43	20/10	140	13.00/3.60	1.30/0.36	82.25	80.820	1.43	1.40/0.70	
L	640	30	10	40	0.978	2.078	3.84	20/20	140	13.00	0.52	81.73	80.81	0.92	1.40	
M	700	60	10	70	1.100	1.100	2.03	10	110	10.00	0.70	81.03	80.750	0.28	1.10	
									BRANCHES							
FFI	60	60	20	10	0.860	1.611	2.98	20	110	10.00	0.80	85.63 84.83	80.440	4.19	1.10	
FIF2	150	90	10	100	0.811	0.811	1.50	10	90	30.00	3.00	81.83	80.640	1.19	1.70	
HH1	70	70	10	10	1.027	1.027	1.90	10	90	30.00	2.40	94.46 82.06	80.640	1.46	1.70	

1) Losses in Specials are assumed to be equivalent to losses in 10M length.
2) Frictional losses are worked out from Nomogram Which is based on the Hazen Willams formula.
3) Difference in initial H.G.L. and tail hydrant 7.65 M
4) Total frictional losses - 6.87 M
5) Minimum head at M at Ch - 700M - 0.28M
6) Maximum head at A at Ch - 10M - 4.84M
7) Rate of discharge at each hydrant 10lps
8) Design pressure for pipe 2.5 kg/sq.cm.

TABLE - 29

OPERATION SCHEDULE

(IIND FORT NIGHT OF MARCH)

PUNADE M.I. SCHEME

TAL. URAN DIST. RAIGAD

(NOT TO SCALE)

LATERAL NO.	CH. IN M.	CHAK NO.	AREA UNDER EACH OUTLET IN Ha.	UTILISATION IN LPS AT EACH OUTLET	DAYS CONSIDERED AS 14 HOURS											
					1	2	3	4	5	6	7	8	9	10	11	12
- LAT 1 -	- 418 -	1 2 3	27.796	630	60	60	60	60	60	60	60	60	55	40	35	20
- LAT 2 -	- 425 -	13, 14	18.428	450	40	40	40	40	40	40	40	40	40	40	40	10
- LAT 3 -	- 555 -	4	11.275	255	20	20	20	20	20	20	20	20	20	30	30	15
- LAT 4A -	- 800 -	5 A	10.623	240	20	20	20	20	20	20	20	20	20	20	20	20
- LAT AB -	- 870 -	5 B	2.865	65	10	10	10	10	10	10	5					
- LAT 5 -	- 1110 -	6	9.600	220	20	20	20	20	20	20	20	20	20	20	15	5
- LAT 6 -	- 1232 -	7	11.077	250	20	20	20	20	20	20	20	20	20	30	30	10
- LAT 7 -	- 1310 -	8	11.563	260	20	20	20	20	20	20	20	20	30	30	30	10
- LAT 8 -	- 1640 -	9	12.003	260	20	20	20	20	20	20	20	20	20	30	30	20
- LAT 9 -	- 1590 -	10	9.387	215	20	20	20	20	20	20	20	20	20	20	10	5
- LAT 10 -	- 1600 -	1 1	6.383	150	20	20	20	20	10	10	10	10	10	10	10	
- LAT 11 -	- 1740 -	12	9.000	225	20	20	20	20	20	20	20	20	20	20	20	5
			140.000	32201psday	290	290	290	290	280	280	275	270	275	290	270	120
			i. e.	0.1623 mm^3												
			i. e.	5.73 Mcft.												

TABLE - 30

OPERATION SCHEDULE

PUNADE M. I. SCHEME

TAL - URAN, DIST - RAIGAD.

OUT LET NO. - 7

S.R. NO.	CH. IN M.	AREA UNDER EACH FARMGATE IN ha	TIME REQUIRED TO IRRIGATE AREA UNDER EACH FARMGATE AT RATE OF 10 LPS (IN DAYS)	DAYS CONSIDERED AS 14 HOURS											
				1	2	3	4	5	6	7	8	9	10	11	12
1	700	1 - 100	2 . 442		2.442										
2	640	0 - 978	2 . 171		2.17										
3	610	0 - 858	1 . 905				4.347								
4	510	0 - 900	1 . 998				4.169								
5	460/70	1 - 027	2 . 280						6.627						
6	410	1 - 110	2 . 464						6.633						
7	365/150	0 - 811	1 . 800								8.427				
8	365/60	0 - 800	1 . 776								8.409				
9	350	1 - 025	2 . 275										10.712		
10	315	1 - 066	2 . 336										10.743		
11	200	0 - 89	1 . 956								8.00	9.956			
12	110	0 - 678	1 . 505											11.461	
13	10	0 - 319	0 . 708											11.41	
14	0														
		11 - 563	25 . 616 to lps day 296.16 lps day												

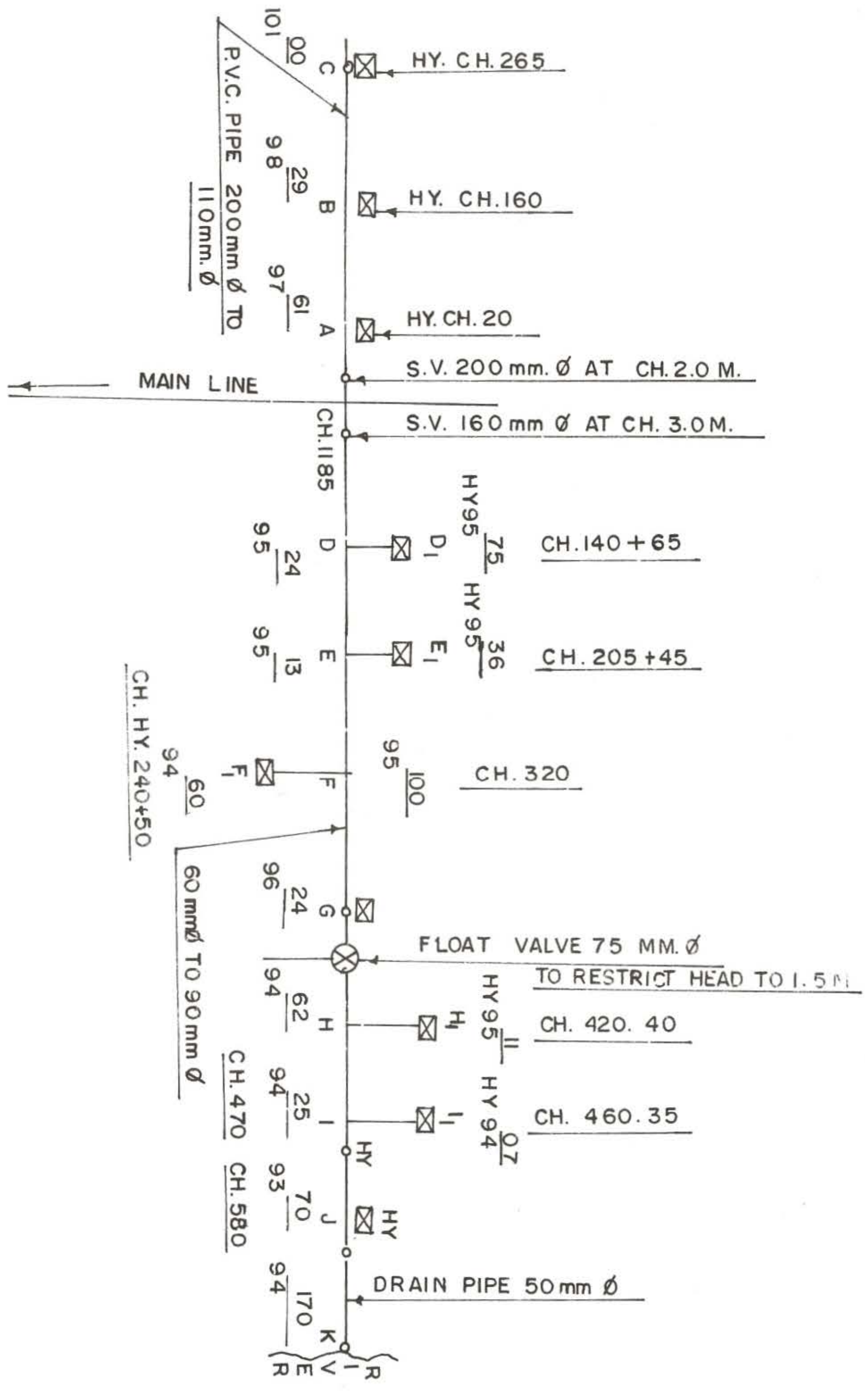


Fig. 42 : Schematic Diagram of Leteral No. 5

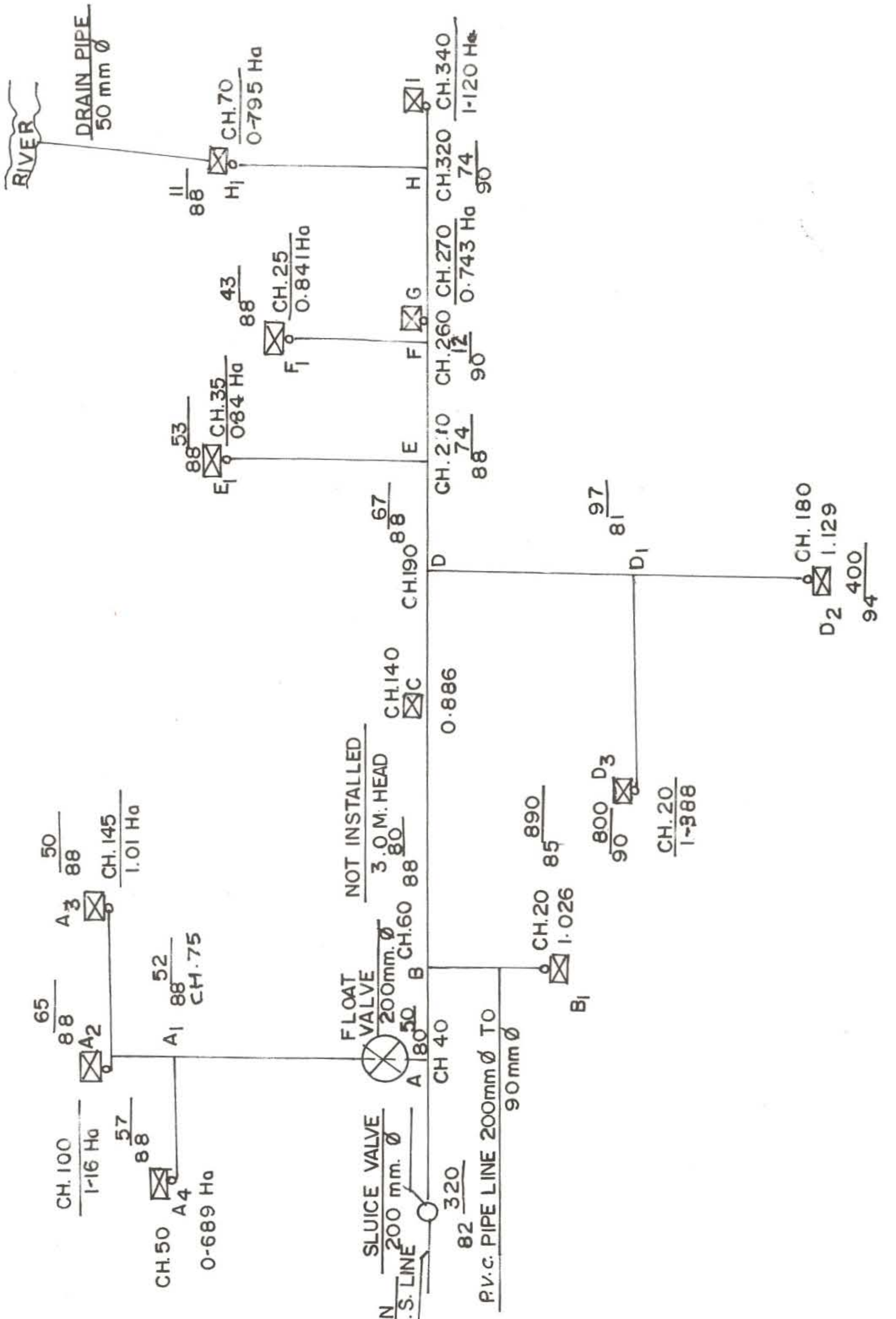


Fig. 43 : Leteral No. 12, Hydrants Wawa M.I.Scheme

N ←

BM	VALUE
⊠ I	87.74
⊠ II	81.78
⊠ III	81.46
⊠ IV	81.48
⊠ V	81.43
⊠ VI	81.21
⊠ VII	81.43

CLOSED PIPE DISTRIBUTION SYSTEM
RWS SAILENT DETAILS

SL NO.	LAT NO.	CHAK	CHAK NO.	AREA OF CUBIC IN Ha	AREA FOR EX-ARR	TOTAL
	1	410	1		9.861	9.861
			2	9.137		9.137
			3	8.798		8.798
	2	425	13 14		9.00 9.428	9.00 9.428
	3	555	4	11.275		11.275
	4A	800	5A	10.623		10.623
	4B	870	5B	2.865		2.865
	5	1110	6	9.600		9.600
	6	1235	7	11.077		11.077
	7	1310	8	11.563		11.563
	8	1360	9	12.003		12.003
	9	1590	10	9.387		9.387
	10	1600	11	6.383		6.383
	11	1740	12	2.289	6.711	2.289
TOTAL				105.00	35.00	140.00

LEGEND

NO.	DESCRIPTION	SYMBOL WORK DONE	WORK TO BE DONE
1.	NALLA, CREEK		
2.	ROAD		
3.	BENCH MARK	⊠	
4.	MAIN CANAL		
4B	MAIN PIPE LINE		
5.	DISTRIBUTION PIPE LINE		
6.	DRAIN PIPE LINE		
7.	HYDRANT	O	o
8	BRIDGE		
9.	LATERAL		
10.	POT HISSA		
11.	CONTOUR		
12.	VILLAGE BOUNDARY		
13.	UNCOMMAND AREA		
14.	UNCULTURABLE AREA		
15.	FLOW PATTERN		
16.	FALL		
17.	CHAK BOUNDARY		
18.	FLOAT VALVE		
19.	AIR VENT	8	8
20.	SLUICE VALVE	□	□

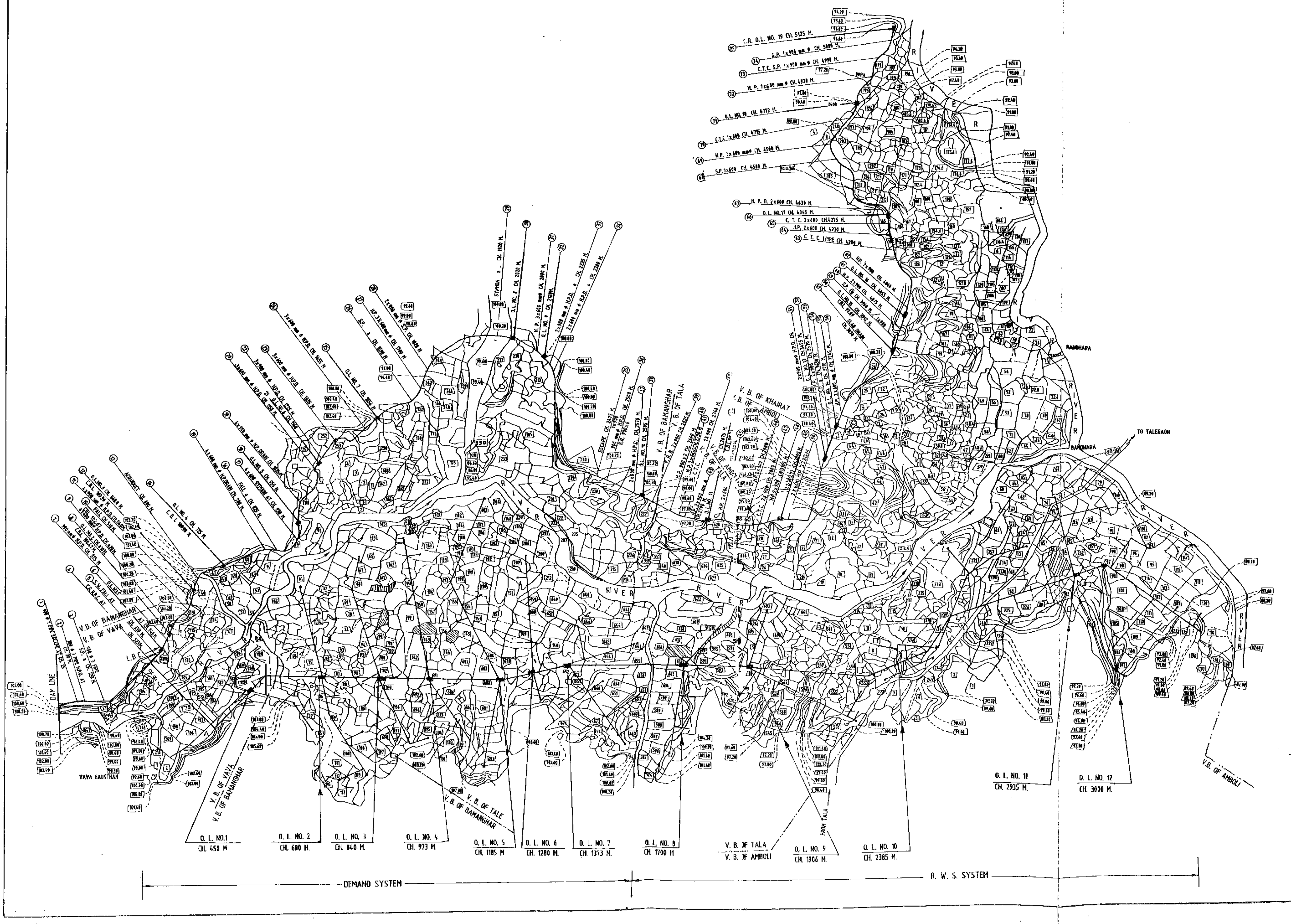
SCALE :- 1 : 2000

GOVERNMENT OF MAHARASHTRA, IRRIGATION DEPARTMENT
THANE IRRIGATION CIRCLE, THANE
RAIGAD IRRIGATION DIVISION NO. II, PANVEL
M.I. TANK @ PUNADE

COMMAND PLAN SHOWING LATERALS AND CHAKS

DRAWN BY	SUB. DIVL. OFFICER P.M.I. SUB. DIV. PNL-II
TRACED BY	
	EX. ENGR. RAIGAD DIV. PNL.

FIG-



CLOSED DISTRIBUTION SYSTEM FOR WAWA RIGHT BANK

OUT LET NO.	CHAINAGE	AREA G.C.A.	AREA I. C. A.	NO. OF IRRIGATOR
1.	450	7.72.7	7.32.0	33
2.	680	11.05.4	10.16.9	24
3.	840	9.65.5	9.06.0	40
4.	973	11.20.5	9.19.9	40
5.	1185	10.78.2	10.51.3	35
6.	1280	8.30.0	8.01.8	34
7.	1373	11.35.8	10.19.9	34
8.	1700	10.57.1	8.40.4	44
9.	1906	13.96.8	11.65.7	29
10.	2385	11.47.8	9.87.9	43
11.	2935	11.62.4	11.05.9	32
12.	3000	12.44.8	11.64.7	50
TOTAL		103.37.0	116.82.4	438

PROPOSAL :

LEFT BANK : OPEN CHANNEL DISTRIBUTION
RIGHT BANK :- CLOSED DISTRIBUTION

DEMAND SYSTEM PIPE LINE OUT LET
NO. 1 TO 7 R.W.S. PIPE LINE
OUT LET NO. 8 TO 12

1.	DAM	
2.	SUBMERGENCE	
3.	RIBLOCK MAIN PIPE	
4.	P. V. C. FIELD PIPE	
5.	GUT NO. BOUNDRY	
6.	POT HISSA BOUNDRY	
7.	NATIONAL HIGHWAY	
8.	STATE HIGHWAY	
9.	MAJOR ROAD	
10.	CANAL/BR/DY/MINOR	
11.	POSITION OF OUTLET	
12.	RIVER & NALLA	
13.	COMMAND OF CHAK OUTLETS	
14.	NOT PROPERLY COMMAND	N.P.C.
15.	VILLAGE BOUNDRY	
16.	WELL	
17.	ALIGNMENT OF F - E	
18.	FIELD DRAIN	
19.	DIVISION BOX	
20.	TEE	
21.	DROP	Z
22.	CROSSING	
23.	MEASURING DEVICES	
24.	UNCOMMAND AREA	

SCALE - 1 : 4000

GOVERNMENT OF MAHARASHTRA
IRRIGATION DEPARTMENT

THANE IRRIGATION CIRCLE, THANE
RAIGAD IRRIGATION DIVISION, KOLAD

DRAWN BY	PLAN SHOWING THE COMMAND AREA O WAWA M. I. SCHEME TAL - MANGAON DISTT. RAIGAD
TRACED BY CHECKED BY	SUB DNL. ENGINEER M. I. SUB DN. ROHA — EX. ENGINEER R I. DN. KOLAD

9.2.5 Buried Pipe Irrigation System Under Construction

In order to achieve the objective of crop diversification and increase in irrigated area, Buried Pipe Irrigation System is contemplated in Konkan Region for the first time at Surya Project in 1984-85. Thereafter, under E.E.C. assistance 57 projects were undertaken for Buried Pipe Irrigation System in 4 districts of Konkan Region. Out of these, some schemes namely Shirval/Pavashi in Sindhudurg district are recently completed. The experience of these projects are quite encouraging and farmers are keen to diversify from traditional paddy to cash crops like groundnut, vegetables, sunflower, etc.

9.3 GADI GALTAR TANK PROJECT IN WEST NIMAR, KHARGONE DISTRICT, MADHYA PRADESH.

This project was visited by the Engineers of Irrigation Department, Government of Maharashtra on 30.01.1991. A brief report on the visit prepared by the Chief Engineer, Irrigation Department, Konkan Region, Bombay is given below :

Gadi Galtar Minor Irrigation tank envisages construction of an earthen dam across river Undari and consists of canal system irrigating tribal belt in Bhagwanpura tahsil of Khargone District. The Gadi Galtar Project has been taken up as a pilot scheme under USAID assisted M.P. Minor Irrigation Schemes. The main components of the project are as follows:

- The main earth dam (872 m long) with saddle dam (566 m long) and a flush bar type spillway 174 m long flumed to 60 m to pass design peak flood of 728 cumecs. Average rainfall in the area is about 1100 mm.
- A masonry head sluice at R.D. 600 m on the right flank to regulate irrigation releases in the main canal.
- Fully lined main canal system 5.16 km long with cement concrete 1:3:6 in bed and concrete tiles on sides. The discharge at the head of the main is 1.89 cumecs. The canal serves an area of 496 ha of upper part of Phase-I.
- An intermediate earthen dam of one day capacity (6 ha m) situated at tail end of main slopping canal.
- A NEYRTIC GATE (Imported) at the head of level top canal to control water level downstream.
- Level top canal 10.96 km long to serve an area of 661 ha in lower part of Phase-II. The distribution network consists of 18 outlets serving an area of 1157 ha through 67 sub chaks.

- The upper part consists of 8 direct outlets and 5 conveyance lines from sloping canal to serve 28 sub chaks covering 496 ha area.
- The lower part consists of 1 direct outlet and 4 conveyance lines from sloping level top canal to serve 39 sub chaks irrigating 661 ha area.

NEYRTIC GATE :

The project consists of 6 ha m capacity intermediate tank to be constructed at the end of main sloping canal so that the flow from main canal exit there into and out of it. Flows from it are automatically controlled AVIO TYPE NEYRTIC GATE at a constant level regardless of flow rate in main canal. It was informed that this automatic control gate was sophistically designed gate and was being imported as similar indegenious designs were not available.

A network of low pressure burried concrete pipeline varying from 200 mm to 750 mm dia supply water directly to each individual holdings. The type of R.C.C. pipes being used in on this scheme have tongue and groove ends for each pipe for jointing purpose. These ends are different from the ends provided on conventional R.C.C. pipes being used in schemes in Konkan Region where conventional butt joints with R.C.C. collars are being provided. The tongue and groove jointing was actually witnessed by the participants.

Special cement - Cement having more fineness than the conventional Ordinary Portland Cement (O.P.C.) is being used for the joint. This is being procured from ACC, Chandrapur as special quality cement. Earlier the project officers were using standard OPC but the joints exhibited cracking and hence on the advice of USAID experts special quality cement - more finer than standard OPC - was experimented. This was proved to be successful and hence is being used.

Neat cement paste was prepared with stiff consistency. The tongue and groove portion of R.C.C. pipe was wetted and neat cement paste applied to the tongue of the pipe already laid earlier. The adjacent pipe with groove and was pushed in position manually. Thereafter cement paste was moulded on the joint to have semi-circular cross section (about 100 mm width, 50 to 60 mm height). This was done for strengthening the joint as instructed by the Project Authorities.

While discussing the merits/demerits of the system, participants expressed the efficiency of the neat cement paste mould as the adhesive to the outer smooth surface of pipe was doubtful. Further, when the pipe joint was subjected to internal hydraulic pressure, the resistance offered by the far end (cement paste moulding) would be virtually negligible and leakage would appear at the base of the moulding. Further, the moulding can not remain in position at the invert portion of the pipe line as the weight would assist separation.

Further, the participants suggested that the use of mechanical jack in pushing the pipe would be more effective and instead of jacking the joint in singular way, if 5 to 6 pipes could be laid and jointed simultaneously and mechanically jacked, the effective strength of joint would be more and progress would increase.

Project officers agreed to take into consideration the above deliberation. Looking to the ease of jointing and reduced cost due to elimination of collar, a few schemes in EEC would be taken up with the tongue and groove type jointing.

The turn out to farm is an ORCHARD VALVE capable of delivering water to farmer upto 30 lps (1 cusecs) and operating for any duration. This is enough to irrigate

1 ha farm in 8 to 10 hrs. The pilot project aims at flexible demand schedule which permits the irrigator to take water as needed at any time, at any rate within the limit, and for as long as he needs it. The farmer has the capability of using the best timing for operation, optimising conditions for planting taking water only in day time to match equipments and labour availability, and turning it off at night.

ACCESSORIES :

The following various accessories are proposed to be installed in underground pipeline system.

Harris float valves : These valves controls volume and level of water in flow conditions it also breaks the pressure at required section.

The project officers informed that they had processed the case for importing of Harris Valves from U.S.A. Till then they were using locally fabricated float valves. Participants informed that in Konkan Region, Government of Maharashtra, one manufacturer was already encouraged to develop better float valve and the prototype was quite good and acceptable quality. Apart from this the tentative price was also very low compared to that of the imported one including foreign exchange and customs duty.

Orchard Valves : Water used by farmers will be controlled by this valve which has convex smooth cover that will not trap debris of water.

Type MO/MD 308 : These meters are bolt on saddle type fixed on concrete pipe. They measure flow of irrigation water.

Line Gate A : Hub end gate for installation in pipe line gates should withstand 60 maximum seating pressure, 10 maximum unseating (back) pressure.

Alfalfa Valves : To deliver water to the surface from concrete pipe line at desired location. Maximum operating heads' 25 and Maximum static head 50'.

The design and execution of piped distribution system at Gadi galtar Minor Irrigation scheme is being carried out under the guidance of Mr John L. Merriam, Technical Expert from USAID. The project execution has been taken up recently and works are in progress. A visit to the scheme next year when works will be in advance stage of completion will be useful.

FARMERS ORGANISATION :

The farmers organisation forms a separate component of this pilot project. The farmers in a subchak share the irrigation water received from a common source. The organisation farmers at chak level will enable them to coordinate their farming schedule vis-a-vis the irrigation supply. It will also be responsible for collection of water charges.

With 68 sub-chaks in the project area it becomes imperative that a group of 6 to 8 sub-chaks be aggregated at a higher administrative level for organisational efficiency. About 10 chaks will be organised to coordinate the operation of sub-chaks. All the chak leaders will automatically form the Board of Directors of Gadi Galtar Sinchai Krashak Sangathan. The Board will establish the policies relative to overall objectives of the organisation for effective and efficient operation of the new system.

The programme of farmers organisation has been taken up under the guidance of Mr Ted Ehers, Sociologist. The programme will provide training to farmers in organisation management, requirements of the system, participation of farmers in planning and operation of system.

9.4 KHOR TANK PROJECT IN DHAR DISTRICT, MADHYA PRADESH

This Project was visited by Engineers of Government of Maharashtra on 31.01.1991. Details of the Project in brief are given below :

Khor Minor Irrigation Tank consists of an earthen dam 420 m long with a surplussing arrangement to pass a design peak discharge of 269 cumecs and a sluice with a design discharge of 0.87 cumecs to regulate irrigation releases in canal. The project will provide irrigation facilities to 370 ha in 5 villages (286 ha of Kharif and 240 ha Rabi). The Khor Tank Project has been taken up under USAID assisted M.P. Minor Irrigation Scheme.

CANALS : The canal system of this project consists of 8.7 km main canal with a head discharge of 0.185 cumecs. The main canal is lined for a length 8.1 Km. There are 11 outlets taking off directly from the main canal. The command is divided into 13 chaks. The micro disnet consists of

1. PVC underground pipeline with inlet chambers, risers, and air release valves, etc. for chak Nos 1 & 5 to 13. The total length of PVC pipeline is 13.58 Kms.

2. Open water courses and field channels fully lined with half round reinforced cement concrete pipes for chak No 2 to 4. The length of water course and field channels is 5.91 Km.

Irrigation on 38 ha has been done under the project during 1989-90 (Kharif 14 ha and Rabi 24 ha).

Khor Minor Irrigation scheme has been selected as a pilot project to experiment pressurised pipe system for distribution and delivery of irrigation water. Distribution network alongwith main canal has been designed so as to command the entire area as best as possible. A minor 455 m long has been introduced at the tail of canal with PVC pipe without pressure flow, has been provided to command available area with linear design. The overall approach for the design of delivery system below outlets has been rigid PVC loop layout as far as possible. Out of total 10 chaks, 8 chaks have been provided with the loop layout according to topography. The main design feature are as under :

1. Capacity criteria for the outlet has been adopted as 0.45 lit/sec/ha.

2. Chak size has been limited to 40 ha approximately.

3. Irrigation in the chak is proposed to be completed in 7 days running period with next irrigation after 14 days interval as per warabandi programme.

4. PVC Class-II pipes 140 mm 110 mm and 90 mm with a pressure of 4 kg/cm^2 have been used.

5. PVC pipes will be buried to a depth of about 1 m to 0.75 m below ground level to protect from damages by farming operations, soil cracking, traffic crossing, etc.

6. Risers have been proposed at the highest critical level for an individual holding or a group of holdings. Each riser serves a block of about 2 ha.

7. Layout of loop is so arranged that the length of farm channel is limited to 200 m from the riser. Unlined farm channels from the riser will be responsibility of farmers to construct and maintain.

8. Air/vents/Air release valves are proposed at an interval of 200 m or at higher points to control vaccum, water hammer and allow exit of entrapped air. The top of air vent has been extended upto 0.60 m above the Static Hydraulic Gradient.

9. The water will be delivered from canal through an A.P.M. (Automatic Proportion Module) outlet into an inlet chamber which will be further carried into a stand post by 140/110 mm dia PVC pipe. From the stand post the water will be passed through 110/90 mm dia PVC pipe. The pipe size in each case is kept the same regardless of discharge, as the length involved and cost difference are marginal.

10. The water will released for irrigation through 1 riser at a time.

11. Rotational water supply/warabandi is adopted for operation of the system.

LOOP SYSTEM : Eight chaks at Khor Tank Project are provided with loop layout of PVC pipe. The PVC pipeline for distribution off takes from the standpost and is again joined to the parent pipeline at the stand-post after running around the command in a loop shape.

The PVC pipe system being adopted in Konkan Region runs in tree system because of the very small holdings (0.2 ha to 1.0 ha) and terraced fields. Therefore, there will be a large variation in discharge from head to tail of pipeline. This variation can be modulated if a loop system is adopted. It is felt that loop system can be adopted on one of the M.I. Schemes with piped systems in Konkan Region particularly when two or three hydrants are simultaneously running on a pipeline in a single chak.

A copy of design and layout of a typical loop in a chak is enclosed.

9.5 GIRI IRRIGATION PROJECT IN SIRMOUR DISTRICT, HIMACHAL PRADESH

This project also was visited by the Engineers of Irrigation Department, Government of Maharashtra from 22-23 January, 1991 and a report was prepared.

Giri Irrigation Project was first commissioned during the year 1980-81 covering a total culturable command area of 5263 ha. The latest cost of the project is 8.23 crores. The source of water for the project is the tailrace of Giri Bata Hydel Project. The tailrace water of the hydel project is collected in the balancing reservoir at Girinagar. A diversion weir has been constructed across Golu-Ka-Khala which carried the tailrace water creating an artificial balancing reservoir capable of holding 1,20,000 cum of water, which is equal to 12 hrs peak demand of irrigation system. The main canal is 2 km long having a carrying capacity of 110 cusecs. The main canal bifurcates into left and right bank canal. The features of the canal are as below:

Sl. No.	Features of the Canal	Left Bank Canal	Right Bank Canal
i)	Length	22 Kms.	17 Kms
ii)	Capacity	50 Cusecs	60 Cusecs
iii)	Distributories with RCC Pipes	8 Nos	10 Nos
iv)	Outlets	12 Nos	18 Nos
v)	Acquaducts	25 Nos	3 Nos
vi)	Syphon	5 Nos	12 Nos
vii)	Area Irrigated	2492 ha	2771 ha
viii)	Lift Irrigation Schemes	9 Nos	8 Nos
ix)	Villages benefitted	22 Nos	25 Nos

The proposed cropping pattern for the project is as follows:

Sr.No.	Name of Crop	Percentage
	KHARIF	
1.	Paddy	50%
2.	Maize	10%
3.	Oilseeds	16%
	Cotton folder	
	Vegetables	----------
	Total	76%

Sr.No.	Name of Crop		Percentage
		RABI	
1.	Wheat		60%
2.	Sugar Cane		10%
3.	Other Crops		20%

		Total	90%

In order to increase the utilisation a command area development programme costing Rs 377 lakhs was taken up in 1985-86. The following provisions have been made in the project of CAD Programme.

Sl. No.	Item	Area ha.	Provision cost/ha.	Remarks
1.	Field Channels	6761	2500	Giri Project on few M.I.S.
2.	Land Levelling	1500	600	Giri Project
3.	Field drains	1500	4000	Giri Project
4.	Warabandi	6761	300	Giri Project

GIRI HYDEL PROJECT

A barrage has been constructed on Giri river and water is letout through a 12 km long tunnel to Giri Hydel Scheme. The R.L. at barrage is 615.40 m and the R.L. at centre line of turbine 433.20 m. Two vertical shaft, francis turbines of 30 MW capacity have been installed. A penstock 2.5 m dia, and 547 m long with a discharging capacity maximum 1700 cusecs and minimum 700 cusecs supplies water to turbines.

Visit to Distributory System "SUWA" R.D.2370/Distributory No 7 - Left Bank Tehsil - Peonta Sahib.

The distributory No. 7 on left bank canal irrigating an area of 70 ha was visited on 23-01-1991. R.C.C. pipes have been used for main distributory for following reasons.

1) There was land acquisition problem in the area and about 2% to 4% area has been saved due to installation of underground R.C.C. pipes.

2) The canal was being tampered with by the farmers frequently for disruption of irrigation facility.
3) Installation of underground R.C.C. pipes would ease the movement of field equipments.

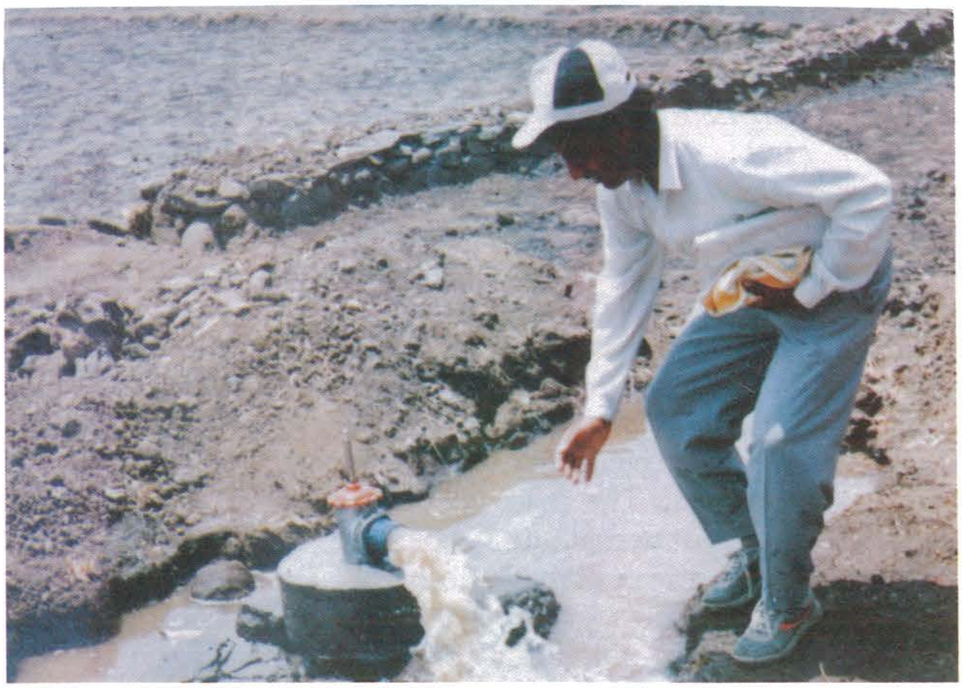
R.C.C. pipes ranging from 150 mm to 600 mm dia have been used.

The project officers enquired about the experience of R.C.C. pipe jointing in Irrigation Department, Maharashtra, because they were experiencing that quite often they experienced leakage of joints long after R.C.C. pipe line was laid and put into commission. From the method of jointing, it transpired that they had not adopted the system of putting up a hemp rope dipped into hot bitumen, Cooled in water and laid between the butting ends of R.C.C. pipes. Further, they had not practiced the method of mechanically jointing the R.C.C. pipes so that the bitumen from the hemp rope squeezes out and makes the joint water tight. The coller joint with hemp core and cement mortar with 1:2 ratio gives strength to the joint but basically it is the hemp rope dipped in bitumen which primarily resists the leakage of water. The coller joints further adds to the leakproof quality of joint. The system was extensively being used by Environmental Engineering Organisation for their pressure pipe lines for the farm is 13 tubewells. Two balancing tanks of 5 acre feet capacity have been constructed. Each farm plot is about 15 acres (990' x 660'). The pipeline is laid along the width of the plot.

A closed loop system of pipeline has been adopted at the farm. The irrigation is generally given for 10 hours during day, while the pumping is done for 20 hours. The water lifted through pump during night is stored in the balancing reservoir. The same pipeline is used for pumping water and distribution of water for irrigation.

The hydraulic laboratory showing different hydraulic structures such as drops, V-notch, flumes, turnouts, measuring devices, etc. were seen.

The drip irrigation system and glass house at the farm were visited.



Water flow at Hydrant at lateral 4A

Filling trench lateral - 3, ch. 630 m.

CHAPTER - 10

CONCLUSIONS AND RECOMMENDATIONS

10.1 Considering the scarcity of water, it is recommended that irrigation in command shall be popularised through pipeline distribution system.

Local pipe fabrication industries should be encouraged and given incentives and avoid excessive transportation cost of pipe. Concession in various excise duties should be given to keep less manufacturing cost of pipe.

Large scale pipe manufacturing industries should be established.

The Planning for deriving maximum benefits from pipeline distribution system should be effectively implemented.

Farmer is the primary beneficiary of the system. His involvement should be given prime importance for maximisation of production.

For accurate climatological data, climatological stations should be installed in the command.

For perishable agriculture products, market facilities shall be made available.

10.2 a) In case of major and medium projects,instead of the minors and field channels, low pressure pipeline system for irrigation should be adopted.

b) In case of minor irrigation project, entire distribution system may be of pipeline.

10.3 There is substantial water saving over conventional open channel system. The pipe line distribution system should be preferred where land cost is comparatively high and farmers are reluctant for sparing the valuable land.

For judicious use of water the modern techniques namely sprinkler and drip irrigation can be enlarged. The pipe line distribution system would be more suitable implementation of advance techniques.

10.4 It is recommended that in case of excessive seepage and trouble of burrowing animals, the pipeline distribution system should be preferred. Canal falls and steep gradients are most favourable for introduction pipe line distribution system.

10.5 Operation and Maintenance Cost is minimum compared to conventional irrigation.

Advanced material like PVC - RIBLOCK, Fibre Glass-RP is more suitable because of low cost, light in handling and smooth finishing and easy repair facility.

10.6 Necessary O & M

Training to users, technocrats and O & M staff should be imparted. The Agriculture Universities be associated with training programme.

Manuals in easy local languages may be prepared and made available to users.

O & M of pipe distribution though less expensive technically may prove to be trouble-some due to chances of theft and lack of spare parts. Precaution against this situation may be devised.

On the upstream of the canal is generally left as uncommended which would be brought under command due to availability of hydraulic head in a close pipe.

Research Centre for evaluating better materials and water management practices should be established.

Review and monitoring panel at Centre and State level should be established.

By way of diversification in cropping pattern viz. horticulture, cash crops other than traditional paddy particularly in high rainfall area.

10.7 The use of computer is recommended for planning designing operation, monitoring review of pipeline distribution system.

10.8 If site conditions permit, the command less than 25 Hectares shall be irrigated through pipeline system invariably. There shall be general consensus for adoption of pipeline distribution system.

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