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Page

In this Issue

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Introducing Foam Concrete to Building Industry in Pakistan

By

Ashfaq Hasan*, M.Sc. Engg. (London),
DIC(London), B.Sc.Engg.(Pb),
FIE(Pak)

BACKGROUND

Foam Concrete, as in well known, is a light weight Concrete in which reduction in weight is obtained by entrapping gas bubbles. Foam Concrete differs from ordinary dense concrete in the sense that it does not use stone pebbles. The manufacture of Foam Concrete requires Cement, Lime and sand all of which are abundantly available in Pakistan. Gas bubbles are produced by adding Al-powder. When water is added to the mixture of cement, lime, sand and Al-powder, hydrogen gas is generated which promotes the mass to swell in volume - swelling being of the order of 3 to 4 times the original volume of the mixture. The product so obtained is cured under saturated steam pressure after which it forms a chemically stable and strong compound namely "Mono-calcium Silicate hydrate". Foam Concrete was first produced in a laboratory in Stockholm in 1923-24 where the first plant was installed in 1929. Since then, the product has gained quick popularity in all the European Countries in different trade names. But almost all European manufacturers have borrowed the technology from Sweden and by now according to rough estimate, more than 150 plants producing about 2 million Cft of Foam Concrete per day are already in operation in the world. Foam Concrete is manufactured and marketted in different trade names. For instance in Sweden and England, it is marketted in the trade names of 'DUROX', 'YTONG' & 'SIPOREX' of which about 100 plants are functioning in various countries. In Poland, it is produced byby two manufacturers under trade name of 'CEKOP' and 'UNIPOL'

* *Member (Technical), Planning & Development Board, Government of Punjab, Lahore.*

who have the distinction of having installed more than 50 plants of Foam Concrete in various countries including Egypt, Lebanon, India and Kuwait. In Holand, Foam Concrete is manufactured under the trade name of 'CALSILOX' who have installed 5 plants including one in Japan. In Bulgaria, Foam Concrete is produced by a firm called 'Techno Export' whose process differs from all other processes, and it is the only process which employes Carbon Dioxide for curing of the product instead of autoclaving. In Russia too, Foam Concrete is quite popular but its details are not readily available for inclusion in this paper.

Eversince its invention, the Foam Concrete has been extensively used in all types of buildings. In Sweden for instance, about 70% of roofing in all industrial buildings constructed between 1960-62 consisted of Reinforced Foam Concrete panels. In Liverpool, the Ford Motor Company used Reinforced Foam concrete slabs for roof over an area of more than one million Sft. which is probably the largest single example. Foam Concrete has also been used in low cost housing in Congo, Mexico, Cuba and Brazil. As wall panels, Foam Concrete has been used in high rise building upto 11 storeys height in Sweden. The tallest Building in Mexico known "Torre LATINO AMERICANA " has made extensive use of Foam Concrete owing to its lightweight and high earthquake resistance. It is impossible to recount all the instances of use of Foam Concrete in buildings in various parts of the world owing to scanty literature but a fair idea can be had from the fact that the total world production of Foam Concrete, which is in the neighbourhood of 2 million Cft per day. However, some of the documented examples of use of 'Siporex' (one of the 6 commercial products) are given below for interest:

i) Western Apartment Building Montreal Canada.

ii) Tyre Factory in Vienezuela.

iii) Stalheim Hotel, Norway.

iv) Brabant Pavilion at the 1958 World Exhibition in Brussels.

v) Fire resistance Oil Storage Building, Denmark.

vi) Ergee Hoisery Factory Germany.

vii) Gardimex Factory at Ennis, Cop Clare, U.K.

viii) Borg-Warner Ltd., Factory Extension at Letchworth, Herts, England.

ix) House at Gracemount Drive, Edinburg.

x) Burdie house Church, Gracemount Drive, Edinburgh.

xi) Aerograph Devilbiss Ltd., Factory at Bournemouth, England.

xii) Priory Acres' - Private house at St.Andrews, England.

xiii) Houses for Basildon Development Corporation, Essex, England.

xiv) Schweppes Production and Bottling Plant, Gateshead, England.

xv) Blackwood Hodge Depot at Cumbernauld, U.K.

xvi) 50,000 Sft Factory roof in Hertford-shire, England.

According to one of the brochures of Siporex, more than 30 million sq.yards of roofing has been laid in Reinforced Foam Concrete Slabs. Therefore, Foam Concrete has proved and established its utility over the course of time. The material is dimensionally stable, has high thermal insulation, good fire resistance and can be designed to take live load upto 100 lbs. per sq.ft. Foam Concrete has the added advantage that it can be sawn, chiselled, cut, drilled and nailed just like wood and its density (weight per cubic foot) is almost equal to that of timber.

MANUFACTURE OF FOAM CONCRETE

The Foam Concrete is being manufactured in various trade names by various firms who also manufacture the equipment required. Complete details of manufacturing processesare generally a trade secret. From the scanty description

given in the pomphlets, sufficient informations can be gathered which is briefly described below for interest:

i) Swedish Process

Foam Concrete is being manufactured in Sweden since 1929 on the basis of research conducted by Dr. AXEL ERIKSSON at Stockholm Institute of Technology. The first factory was established by Messrs DUROX in Sweden. Since then the material gained considerable popularity and is being manufactured under the trade names of 'YTONG', 'SIPOREX' and 'DUROX', all of whom have established their subsidiaries and plants in various countries of the world. By now more than 32 Siporex Plants and more than 35 Ytong Plants are reported to have been installed in various countries. All the processes utilize cement, lime, sand for production of Foam Concrete in which Al-powder is used as gas generating agent. The exact quantities of materials used by various processes is not known except for Ytong whose ingrediants (by weight) for Foam Concrete having density of 31 lbs/Cfr are given below:-

Cement	1
Unslaked lime	4
Sand	11½
Al-powder	0.09% of total wt.

The manufacturing process involves wet grinding of sand into a slurry which is stored in special silo. The burnt lime (precrushed to 6 mm size) is ground in a separate Silo. Weighed quantities of sand slurry, cement, lime alongwith Al-powder and water are fed in a vertical mixer. The liquid paste is then poured into steel moulds and allowed to expand and harden, after which the green Foam Concrete with mould is tilted through 90° on end and the mould is removed, leaving the vertical panel to rest on

curing plate. The product is then cut vertically and horizontally by wire cutters and fed into autoclave about 9 feet diameter and 120 feet long and subjected to saturated steam pressure of 12 atmospheres for 12 hours. The final product has a compressive strength of 215-850 psi for densities ranging from 25-40 lbs per Cft. In producing Reinforced Foam Concrete slabs, welded steel mesh is coated with Cement Rubber Latex before placing in the moulds. The process is fully mechanised involving a labour force of only 114 workers for a plant designed to produce 12,000 Cft Ytong Foam Concrete per day in two shifts. The cost of complete plant imported from Sweden is estimated to be about Rs.2.0 crore for production of 12,000 Cft Foam Concrete per day.

ii) Dutch Process

The process was developed by a Dutch Firm "LOEVESTEIN GROUP" in 1953 having trade name CALSILOX. Since then, the firm has installed 3 plants in Holland one in France and one in Japan. The process involves grinding of main constituents (i.e. cement, lime, sand in the ratio 1:2:7) to a fineness of "Wheat flour" in a ball mill. The ground mixture is fed into Foam Concrete Mixer alongwith Al-powder (0.08% by weight of dry material) and sufficient water, with Teepol detergent at the rate of 0.5 lb per Cft to reduce surface tension to bring it to thick creamy consistency. The quantity of mixing water required for the production of CALSILOX (inclusive of steam) is reported to be 10 gallons per Cft. The mix is then poured into steel moulds and left to dry and expand for about 3½ hours. The green Foam Concrete is then cut into blocks by wire cutting machine without removing the bottom of the mould. The Foam Concrete (with mould bottom) is then stacked in three tiers on a trolley and is placed in an autoclave under steam pressure of 12 atmosphere. The time required for curing of Foam Concrete in autoclave

is reported to vary from 15-22 hours. The cured Foam Concrete is reported to have a compressive strength of 700-1000 psi depending upon the density (34 to 44 lbs/Cft) when tested in dry state at 70°C.

The entire manufacturing process of drying the ingredients, weigh, batching, grinding and mixing including cutting, handling and transport is fully mechanised. The average quantity of steel used in reinforced CALSILOX is about 2 lbs/Cft. The reinforcement is welded and is coated with rust proof paint (INERPOL DIN 4223) of which ½ lb is required for every lb. of steel used. The total number of persons employed for producing CALSILOX varies from 55 to 108 for one shift work for a plant manufacturing about 12,000 Cft of Foam Concrete per day. The cost of importing the plant from Holland is not known.

iii) Polish Process

The process was developed by the manufacturers on the basis of experience gained from installation of a Swedish plant erected in 1949. Later on, the Polish Scientists and technologists developed their own experience and started manufacturing their own plants with their own patent formula on the basis of the Polish Universal Production Method by the trade names CEKOP & UNIPOL.

a) 'CEKOP'

More than 250 million Cft of Foam Concrete per year is being produced in 40 CEKOP plants in various countries. The ingredients are basically the same as in other processes. The mix consists of Cement: 1, Lime: 4 and sand: 18 by weight to yield Foam Concrete of 44 lbs/Cft. The ingredients are mixed and ground together in tube mill upto fineness of cement. The

ground materials are fed in a vertical mixer alongwith 0.04 to 0.05% of Al-powder by weight. The required quantity of water is also added in the mixer to form a slurry. The following basic chemical and physical changes take place inside the mixer and the mould:

- Burnt lime is transformed into hydrate of lime.
- Aluminium powder is contact with the hydrate of lime produces hydrogen in millions of tiny bubbles with the result that the mass "grows" like 'Kneaded bread flour'.
- The expanded mass sets in about 2-3 hours upto cheese-like consistency suitable for cutting.

The half hardened mass is then cut by steel wire after removing the sides of steel mould. Where Reinforced Foam Concrete is produced, welded steel mesh coated with Cement Rubber Latex as "anticorresive paint" is placed with the desired cover into the mould before filling it with the slurry. The moulds are then stacked (3 high) in a steel trolley and introduced into autoclave for curing. The autoclave is usually about 10 feet in diameter and 100 feet long in which saturated steam at 12 atmosphere is supplied for curing. The time for curing usually varies from 16-18 hours after which the reaction of Silica and Lime is complete, transforming the mass into a stable Calcium Silicate compound. The hardened Foam concrete is removed from the autoclave after shutting off the steam from the autoclave. The moulds are removed and product allowed to cool. The whole manufacturing process lasts about 24 hours.

As in other process, CEKOP is also fully

mechanised involving about only 100 workers per day for a plant having a capacity of 8,800 Cft production per day on the basis of one shift per day. The cost of equipment quoted to one of the friendly Middle Eastern countries in 1965 was about $1.4 million excluding spares and installation. The present cost of the plant including spares and installation is estimated to be in the neighbourhood of Rs.2.0 crore in Pakistan.

b) 'UNIPOL'

It has slightly different manufacturing process to that of CEKOP using the same raw materials but in a different proportion. Where CEKOP uses a mix in the ratio of 1:4:18, UNIPOL employs the mix 1:2¼:11. Instead of grinding all the raw materials together, a major portion of the sand and quick lime is ground in tube mill in wet condition upto the required fineness to form a slurry. The remaining quantity of sand, lime and desired quantity of cement are ground in another tube mill in dry condition. A weighed quantity of dry mixed powder sufficient for one mould is then fed into a vertical foam mixer to which a required volume of slurry is also added. The following ingredients are also fed to the mixer:-

- additional water.
- wastes of green Foam Concrete.
- Alluminium powder 0.04% by weight.
- Detergent such as 'SULPHAPOL', 'TIDE' or 'OMO' at 1 gm/Cft.

The liquid mixture is cast into steel mould placed directly under the mixer on a steel wagon running on rails. In case of rein-

forced Foam Concrete elements, the steel reinforcement coated with a film of Anti-corrosive substance based on cement and latex is placed inside the mould before filling the liquid paste. The moulds are then pushed to one of the tracks where they are allowed to stay undisturbed for some time for the preliminary setting and swelling of the paste.

When the liquid mixture has hardened enough into soft, porous mass, the mould on the wagon is mechanically pushed to the production line, where the excess overgrown mass over the edges of the mould is removed. The sides of the moulds are also removed and the product cut longitudinally and laterally. The moulds are stacked (2 high) on a trolley and placed in the autoclave for curing which is supplied by saturated steam of about 190°C temperature. The autoclaving process lasts about 16 hours after which the Foam Concrete is pulled out from the autoclave. UNIPOL process is also completely mechanised and requires of 179 workers for a plant having a capacity of about 10,000 Cft daily in 3 shifts. The cost of the plant is not known.

COMPARISON OF VARIOUS PROCESSES

The ingredients and some technical data of 4 major processes described above are given in Table 1. It will be seen that CEKOP process uses minimum of cement, with higher density Foam Concrete than that of YTONG. The curing time in autoclave in the later process is much shorter than that of the POLISH process. The table also shows that Ytong (dry density 31 lbs) has low compressive strength of 425 psi as compared to the POLISH or DUTCH product. The weight of raw material per cum of Foam Concrete in various processes is also given in Table 1.

TABLE 1

COMPARISON OF VARIOUS PROCESSES

Item	CEKOP	UNIPOL	YTONG	CALSILOX
Materials/Cu.m.				
Cement (Kg)	30	50	35	65
Kime (Kg)	120	113	140	130
Sand (Kg)	550	568	400	455
Cost of raw materials (Rs.)	45	48	52	57
Approx. mixing water (Litre)	N.S.	384	N.S.	N.S.
Al-powder (Kg)	0.3	0.3	0.5	0.5
Water cement ratio (Estimated)	4-5	4-5	4-5	4-5
Total water (Litre)	900	N.S.	700	1600
Autoclave size (ft)	8.5x98	8.5x104	9x110	9x115
Mould size (ft)	5.2x1.6x10	6x2x10	4x2x14.5	5x2x20
Hardening time (hour)	3-4	3-4	1-2	3-4
Curing time (hour)	16-18	16-18	12	15-22
Steam pressure (Atm)	12	12	12	12
Dry Density lb/Cft	44	44	31	40
Compressive strength psi	700	700	425	850

TABLE 2

CRUSHING STRENGTH OF FOAM CONCRETE

Product	Dry Density Lbs/Cft	Oven dry crushing strength PSI
Ytong	25-40	215-850
Durox	37-52	500-650
Siporex	31-37	430-560 (air dry)
Unipol	31-44	280-700
Cekop	28-59	280-1050
Calsilox	34-44	700-1000

TABLE 3

THICKNESS OF REINFORCED FOAM CONCRETE ROOF SLABS

Span (ft)	Thickness (ins)	Span (ft)	Thickness (ins)
6	4	13	6½
7	4½	14-15	7
8	5	16	8
10	5½	17	8½
11-12	6	18-20	9

It will be seen from table that the formula used by CEKOP is cheapest whose material cost works out to Rs.131/- per cum i.e. Rs.3.71 per Cft on the following rates of raw materials of 1979:-

-	Cement (per 50 Kg)	Rs. 55/-
-	Lime (per 40 Kg)	Rs. 26/-
-	Sand (per 100 Cft)	Rs. 100/-
-	Al-powder (per lb)	Rs. 18/-

PROPERTIES OF FOAM CONCRETE .

i) Density

The dry density of Foam Concrete produced by various processes varies according to ingredients and the quantity of Al-powder used. Foam Concrete having dry density 31-37 lbs per Cft. is most commonly used; but higher density Foam Concrete of 52 lbs per Cft has also been produced for block construction or higher sound reduction. Since all materials absorb moisture from air, Foam Concrete is no exception, density at the time of delivery is generally 15 to 25% higher than that of oven dry density i.e. 27 lbs Foam Concrete would weigh 44 lbs/Cft at the time of delivery.

ii) Engineering Characteristics

The crushing strength of Foam Concrete varies with the density and moisture just like ordinary Concrete i.e. the higher the density the greater the strength and higher the moisture the lower the crushing strength. The crushing strength of saturated Foam Concrete is generally 33% lower than that of oven dry Foam Concrete. The crushing strength of Foam Concrete produced by various patent methods as claimed by manufacturers is given in Table 2.

According to British Code of Practice 111 on load

bearing walls, the permissible basic stress in walls laid in Foam Concrete blocks (measuring 12" X 6" high) having crushing strength of about 500 psi using 1:8 cement mortar is 50 psi. This can be increased to 100 psi on account of shape of units where height is twice that of its thickness. If the wall is 6" thick and storey height is limited to 9½ ft, it gives a slenderness ratio of 19 and a stress reduction coefficient of 0.48 if eccentricity of 1/6th is assumed as per C.P. 111. This determines dimensions of rooms and number of storeys that can be erected with load bearing Foam Concrete blocks.

Foam Concrete can and has also been used in precast roof slabs to support super imposed load up to 100 lbs/Sft. Typical values of thickness of slab for various spans supporting a superimposed load of 65 lb/Sqft are given in Table 3.

The structural design of Reinforced Foam Concrete is based on the following assumptions by using either the elastic theory or Load Factor method:

Compressive strength	150 to 230 psi
Modulus of Elasticity	0.21 to 0.45x166 psi
Modular Ratio	80-90
Coefficient of thermal expansion per ^{o}C.	8×10^{-6}
Tensile strength	50 psi
Bending strength	1000 psi
Permissible Deflections under working load.	1/275 of span.

iii) Water Absorption and Rain Penetration

The tests carried out in BRS London (II series Digest 16) indicate that Foam Concrete absorbs 21-27% water by volume depending upon density. This compares favourably with dense concrete which absorbs 16% water by volume. On weight

basis (which incidently is a misleading index for Foam Concrete owing to its light weight) the Foam Concrete absorbs 27-50% moisture as against 7% in the case of dense concrete. It has also been shown by Standard Artificial Rain tests that Foam Concrete does not show any staining on the back face when subjected to artificial rain for periods exceeding 6 hours.

The Capillary rise of water in Foam Concrete is reported (BY CALSILOX) to be 3.75 inches after 72 hours. This imposes some limitations for using Foam Concrete below DPC and therefore the manufacturers only recommend its use above the DPC level. Owing to high water absorption, adequate water proofing treatment of Foam Concrete roofs will be necessary.

iv) Thermal Insulation

Foam Concrete has high thermal insulation and is therefore ideally suited for tropical countries such as ours. The thermal conductivity of Foam Concrete varies from 0.81 to 2.1 BTU/Sft/1 h/F° in depending upon the density. On the other hand the thermal conductivity of bricks varies from 5 to 11, while dense concrete has thermal conductivity of 8-12. The most commonly used Foam Concrete having density 37lbs/cu. ft has a thermal conductivity of 0.97, which shows that Foam Concrete wall 6" thick will be thermally equivalent to solid brick wall 2½ feet thick. The heat transmission Coefficient U (which is a real measure of thermal insulation of building shell) of Foam Concrete varies 0.08 to 0.1 which is less than ¼ that of solid brick wall of same thickness, whose U value is equal to 0.36, while a cavity brick wall 11" thick has a U value of 0.27.

v) Sound Insulation

The sound absorption of Foam Concrete inspite of its lightness is said to be 5 times that of dense concrete. Typical values of Sound Absorption

Coefficient from soffits of some commonly used building materials are compared with Foam Concrete (SIPOREX) in Table 4. The actual sound reduction in 6" thick Foam Concrete wall is reported to be 43 db, which is very nearly equal to a plastered 4½" thick brick wall, whose insulation value is 45 db. It must however be recognized that the weakest link in sound absorption in walls is that of glazed windows and door crevices while thickness of walls may be generally immaterial.

vi) Fire Resistance and Earth Quake Resistance

The fire rating of Foam Concrete is much higher than brick wall or the dense concrete. For instance, 5" thick Foam Concrete roof slab & 4" thick load bearing wall has a fire resistance of about 2 hours. While 4½" brick wall has a resistance of only one hour; concrete block wall 4" thick has a fire resistance of 2 hours.

Although no specific tests have been carried out on comparison of earthquake resistance of Foam Concrete with ordinary building materials like bricks and concrete, but Foam Concrete is reported to have withstood the severe earth quake of 1957 in ACAPULCU, Mexico in which the houses did not suffer any damage. The high earth quake resistance of Foam Concrete, as compared to ordinary dense materials, is understandable and is attributed to its lower weight.

ECONOMIC VIABILITY OF FOAM CONCRETE

The economic viability of Foam Concrete not only depends on the cost of materials but also on the cost of plant and other overhead expenses. If a plant is purchased from a European manufacturer after calling competitive bids, the total cost including technical assistance, installation etc. would be in the neighbourhood of Rs.200 lac for a plant having a capacity of 8800 Cft per day. The local expenditure on acquisition of 8 acres of land

and construction of building etc, for the plant will be about Rs.47 lac. On the basis of above capital expenditure the cost of Reinforced and Unreinforced Foam Concrete works out to Rs.20.0 and Rs.12.70 per Cft respectively as per details given in Appendix I. The cost of Reinforced Concrete being used for roofing purposes on the present market rates works out to be about Rs. 40.0 per Cft. Although as compared to ordinary dense Reinforced Concrete (1:2:4) the Reinforced Foam Concrete is apparently about 50% cheaper in price but in actual fact it is not. Against 4" thick Reinforced Concrete slab to support a live load of 40 lbs/Sft, the thickness of Foam Concrete panel required will be about 6 inches , whose cost will almost be equal to that of dense concrete after including carriage from factory and installation.

The main advantage in using Reinforced Foam Concrete instead of Reinforced Concrete will be the reduction of a dead weight by 66% which will yield considerable savings in foundations, size of columns and beams supporting loads in the framed structures. The Reinforced Foam Concrete roofing units when employed in multistorey framed structural buildings will, therefore, reduce the quantity of steel by about 50-60% — an advantage which must be fully exploited in Pakistan owing to shortage of steel in the country.

However, it must be remarked that the consumption of lime will increase considerably as Foam Concrete makes abundant use of lime. The requirement of lime to run a factory having an out put of about 2.6 million Cft of Foam Concrete per year will be about 10,000 tons which together with 2400 tons of cement, will replace 10,000 tons of cement in usual (1:2:4) Concrete for the same area of roofs. Since lime is cheaper to produce than cement, the introduction of Foam Concrete will have a healthy effect on the economy of the country as a whole.

POTENTIALS OF FOAM CONCRETE IN PAKISTAN

The manufacturer of Foam Concrete basically requires materials like cement, lime and fine sand, which are all

abundantly available in Pakistan. The foaming agent viz, Al-powder will, however, have to be imported. Similarly, Rubber Latex for painting reinforcement to prevent corrosion, will also have to be imported. But the quantities of imported material will be insignificant and will be met from the saving in steel and cement. For instance, a plant designed to produce 8800 Cft of Foam Concrete per day, requires only 20-25 tons of Al-powder per year costing approximately Rs.6.0 lac. As regards Rubber Latex, it is estimated that 8800 Cft of Reinforced Foam Concrete will require Rubber Latex of value of about Rs.2.0 lac. The most important and interesting part of Reinforced Foam Concrete is that it utilizes only about 2 lbs of steel per Cft of Concrete as against 4-5 lbs consumed in dense concrete slabs. This singular advantage will reduce the consumption of steel in roofs by about 30% which will give a saving of about Rs.4.0 per Sft of roofs to the owners. Another advantage of introducing Foam Concrete in Pakistan would be that it will reduce the consumption of cement by about 75% in roofs. For instance, where ordinary dense concrete requires 17 bags of cement per 100 Cft sufficient for about 300 Sft of roof, we would require 150 Cft of Foam Concrete using about 3 bags of cement. This will save enormous quantity of cement which could be exported to friendly Middle Eastern countries to earn the much needed foreign exchange.

A factory designed to produce 8800 Cft. of Reinforced Foamed Concrete panels for roof per day will cover about 17600 Sft built up area requiring only about 2400 tons of cement per year as per Appendix I. If dense gravel concrete is adopted, as at present, the cement requirement would have been about 10,000 tons, assuming 4" thick R.C slab. The Foam Concrete roofs would thus yield a saving of about 7500 tons of cement per year or Foreign exchange earning of about $500,000 by export of surplus cement. The net saving after deducting expenditure of $ 60,000 required for import of Al-powder and Rubber Latex comes to $440,000. Assuming a Foreign exchange investment on import of plant as $1.5 million, it is seen that this investment will be returned to the country in only 3½ years only through saving in cement.

In the present technique of the multistorey construction

in Pakistan, brick partition walls 9" thick are generally used mainly because of absence of alternate light weight material. But this technique has been responsible for pushing up cost of construction unnecessarily. For instance, where a 9" and 10' high brick wall imposes a load of about 4 tons on a concrete beam over 10' span, a Foam Concrete wall 8" thick will impose a load of only 1½ ton. This reduction in weight on concrete beam will reduce the requirement of steel by 66% in the structural members. Even if horizontal/vertical Foam Concrete wall panels having nominal steel are used for filling in between columns, the over all saving in steel required in multi-storey construction may be about 50%. Evidently, the use of Foam Concrete in non-load bearing walls in multistoried buildings will affect considerable saving in steel and is sure to have a high potential.

The implementation of low cost housing Schemes of the Government and other building projects in the country has not kept pace with the expectation due to paucity of bricks which are considered as a back-bone of all building activity in major portion of the country. With the introduction of Foam Concrete, an alternate material will be available to relieve the pressure on bricks whose cost in the recent months has risen to Rs.400 per thousand. The use of Foam Concrete will hasten the pace of construction and the usual bottleneck of roofs will no longer be an impediment.

HOW TO INTRODUCE

The manufacturing process of Foam Concrete has been compiled from the printed brochures and quotations of some of the suppliers of the equipment so as to bring this material to the focus of local technologists and Industrialists. Since all the European processes are patented, exact ingredients and correct curing pressure and time for the local material must be determined in the laboratory. It is hoped that Lahore Building Research Station will take positive steps to carryout experimentation by installing a small autoclave and other equipment. Another method of introducing this wonder material

is to install one plant after preliminary studies which can be amended/modified to suit our conditions by experience. The Public sector Industrial Organizations can be persuaded to take up the project.

TABLE 4

SOUND ABSORPTION COEFFICIENTS OF SOME MATERIALS

Type of Concrete	Frequency Cycles/Sec.		
	125	500	2000
Foam Concrete	0.02	0.19	0.34
Smooth Plaster	0.02	0.02	0.04
Rough Plaster	0.04	0.06	0.05
Concrete	0.01	0.02	0.02
Glass	0.10	0.04	0.02

APPENDIX I

PRODUCTION COST OF FOAM CONCRETE ON THE BASIS OF IMPORTED PLANT

1979 (APPROX.RATES)

(Rs. in lac)

I.	**Capital Expenditure**		
	Land 8 acres	...	10.0
	Buildings (35000 Sft)	...	31.5
	Development of Land	...	5.5
	Machinery & equipment including installation and spares etc..		200.0
		Total Capital Cost:	247.0
II.	**Operation Expenses**		
	Materials:		
	Sand 45000 ton	...	9.0
	Lime 10000 ton	...	62.5
	Cement 2400 ton	...	26.4
	Al-powder 22 ton	...	6.0
	Steel 3000 ton	...	150.0
	Other materials like Oil, anticorrosive paint etc. L.S.	...	5.0
	Water 14 million gallon	...	1.1
		Total:	260.0
		Quarterly operation expense:	65.0 lac
III.	**Labour & Overheads**		
	Fuel & Power	...	20.0
	Maintenance	...	10.0
	Labour & Management	...	50.0
	Depreciation 10%	...	25.0
	Interest on capital of Rs.312 lac @ 13%		40.0
	Loan instalment 10%	...	25.0
	Profit & taxes	...	98.0
		Total:	268.0

Total running cost: 528.0 lac

Annual production = 8800 x 300 = 2.64 million Cft.

Sale price of Reinforced Foam Concrete per Cft.

$$= \frac{52.8}{2.64} = \text{RRs.20.0 per Cft.}$$

In order to produce Unreinforced Foam Concrete blocks, the expense on reinforcement and anticorrosive paint amounting to Rs.154 along with interest of Rs.5 lac on this outlay will have to be deducted. Assuming the increase in production rate of 10% when producing unreinforced blocks, the sale price will work out to Rs. 12.70 per Cft. as given below:

Total running cost = 260 - 154 + 268 - 5 =Rs.369 lac

Production = 29 lac Cft.

$$\text{Cost/Cft} = \frac{369}{29} = \text{Rs.12.70 per Cft.}$$

The Problem of Rail and Road Level Crossings

By

Saleem Akhter Bhalli*

1. DEFINITION

The crossing of a railway track with a road, like any highway intersection, involves either a separation of grades or a crossing at grade. The grade separation results in either an over bridge or an under bridge. The at-grade intersection is called level crossing in our country.

2. OBSERVATIONS & STUDIES

(a) The traffic on most of the highways has increased tremendously during the present century and the number of trains passing over these tracks and the length of trains have also increased manifold with the result that the number and duration of closures of gates on level crossings has increased many times than before. In fact, the very necessity of improving the at-grade crossings or construction of grade separations has arisen because of the everelongating closure periods of the gates, necessitated due to increased train passings.

(b) A Survey of traffic hold-ups on the rail and road level crossings in the Punjab has been carried out and sample counts have been recorded. Simultaneously, the survey of general flow of traffic has also been carried out near each level crossing on the same day. The total time of closure per day and number of closures have also been recorded in order to know the true picture of traffic at each level crossing. The result of this sample count of road traffic and the surveys of hold-up traffic have been consolidated route-wise. The result of the counts of both the traffic survey and hold-up traffic has been converted into passenger Car Units (PCU). Motorized

* *Chief Physical Planning & Housing, Planning & Development Department, Lahore.*

and non-motorized vehicles have been counted separately category-wise. The number of gate closures and the total time of closures in 24 hours have been noted down. Moreover, a planetable survey has been conducted at each level crossing to have a complete idea of the layout and location of each level crossing in the Punjab.

(c) The held-up time has been observed and efforts have been made to evaluate the same. During these observations following peculiarities were noticed:-

i) On rail-road crossings falling within urban limits it has been noticed that the gates are closed to traffic too frequently and in some cases only half the traffic is cleared in-between the closures.

ii) Although the time of the traffic hold-ups is taken to be the actual time of closure of the gates, the traffic takes additional time in disposal because of its mixed composition (motorised and non-motorised) and because of insufficient roadway capacity at the level crossings as well as approaches.

iii) Since traffice control management at rail and road crossings for the held-up traffice is not provided, the mixed traffic from both directions, invariably causes traffic jams on the railway track as well as on the approaches. (The long term consideration, of course, would require a grade separation, if it is economically justified and technically feasible).

(d) Grade separations play an important role in urban development, help generate economic activities and increase the efficiency of transportation of freight and passengers. In populous cities the rail and road crossings are at present causing acute problems to road transport during peak hours and the best solution is evidently a grade separation of the two opposing types of traffic viz. the rail traffic and road traffic. This solution, however, is very expensive and cannot be afforded by the

national economy in all situations save at inter-section points of heavy rail and road traffic, especially within the urban limits.

In other countries where such problems have been more thoroughly gone through and valuable experience gained, it has been specified that where a railway track and a road cross, grade separation is to be carried out when the average daily traffic exceeds 4000 vehicles and the number of trains is 6 or more. The specification is graphically represented in Figure-I which has been adopted after American practice and was also recommended by the former World Bank Consultants to the West Pakistan Highway Department. This graph indicates various combinations of the rail and road traffic justifying grade separations. As implementation of these specifications may not be possible in view of financial restraints, we have to be contented with providing mostly level crossings but of reasonable geometric standards.

(e) Frequent gate closures and awkward approaches at curves combined with prolonged hold-ups at closure time are serious handicaps to the highway user in the form of increased travel time, travel cost and inconvenience.The extent of improvements required at each level crossing should be a function of the quantum of road and railway traffic, particularly the road traffic. Accordingly the Vice Chairman, P.W.R. had rightly suggested to the Secretary Railway Board, vide his Memo No.480-W / III (DUP) dated 24.12.1966, that as the old specified widths of level crossings as per para 382(2) of the Way and Works Manual were not in consonance with the single lane or double lane concept of highway traffic, therefore, the Railway Board's approval be sought for the following gate widths:-

Special Class.	42 ft.
A Class.	32 ft.
B Class.	24 ft.
C Class.	12 ft.

The rationale of the suggested gate widths by the P.W.R.

FIGURE -1

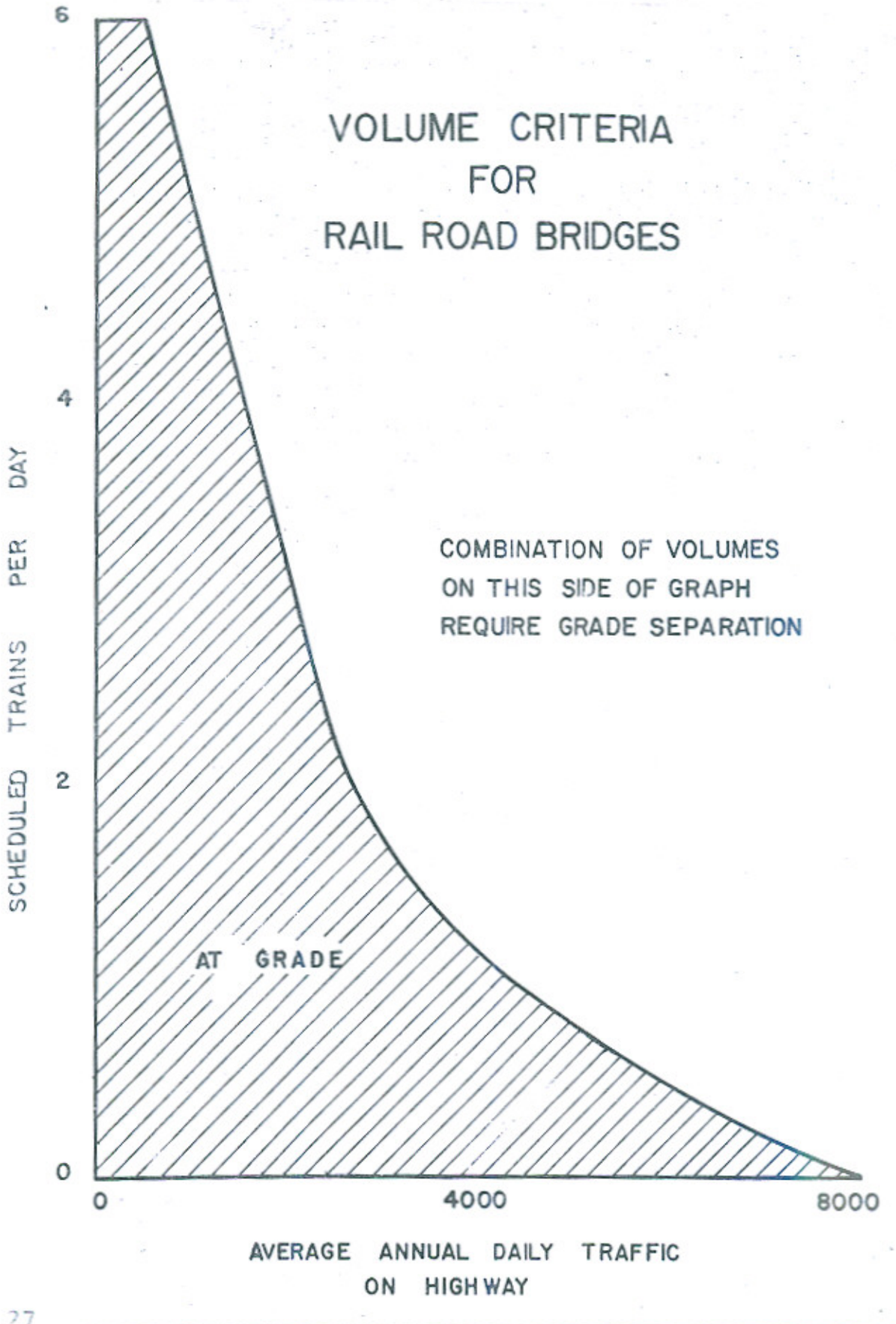
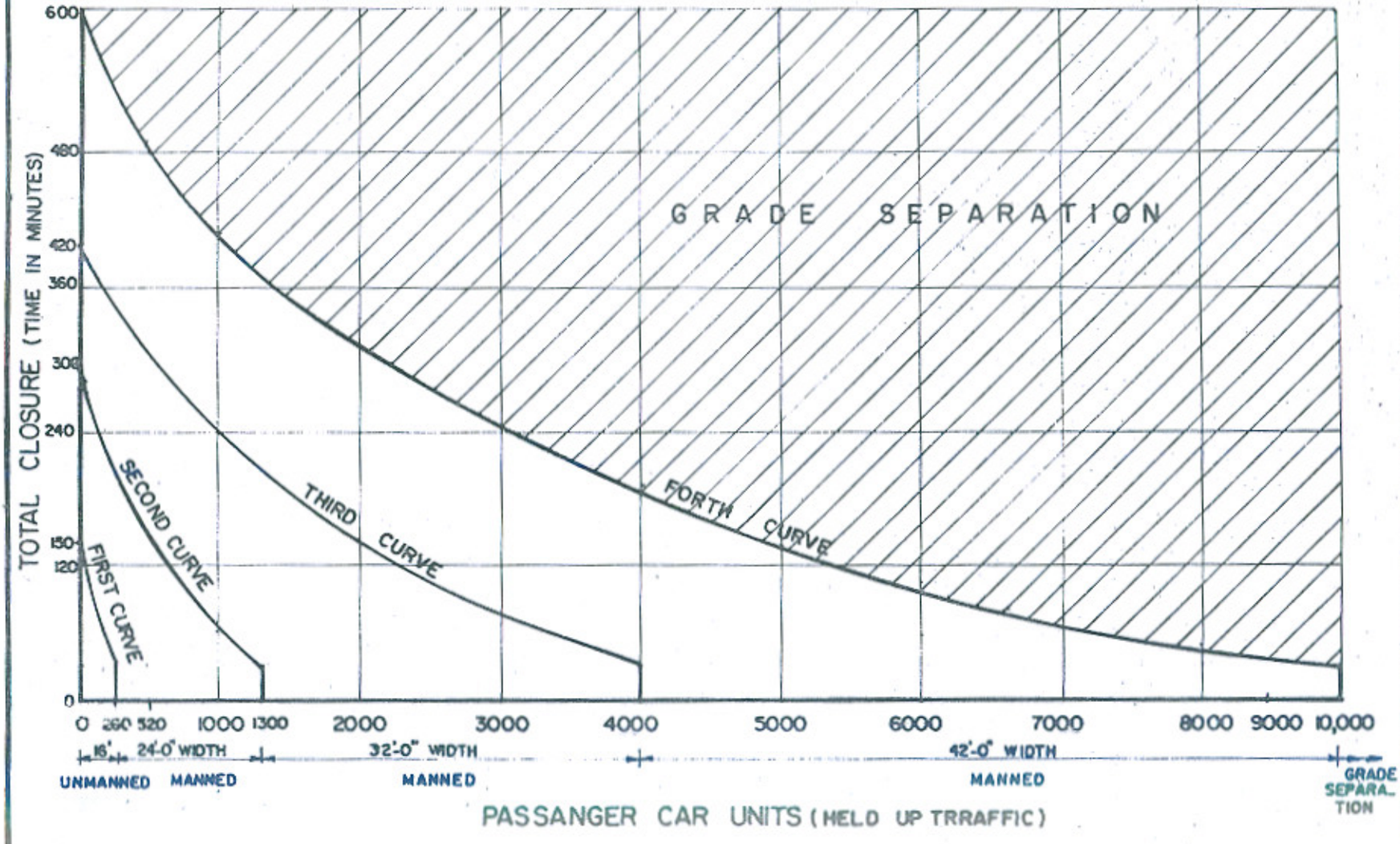

VOLUME CRITERIA
FOR
RAIL ROAD BRIDGES
COMBINATION OF VOLUMES
ON THIS SIDE OF GRAPH
REQUIRE GRADE SEPARATION
AT GRADE
SCHEDULED TRAINS PER DAY
6
4
2
0
0
4000
8000
AVERAGE ANNUAL DAILY TRAFFIC
ON HIGHWAY

FIGURE - II

GRAPH OF CLOSURE TIME Vs GATE OPENINGS



was, however, not established at that time except B-Class level crossing which appeared to be in accordance with the concept of 2 lane width of road. As the level crossings are meant for passing the road traffic, the geometrics of the level crossing including width must conform to the requirements of the road.

(f) However to assess a reasonable width of gate opening at a level crossing, a relation between the total time of closure instead of the number of trains, versus the held-up traffic per day has been established to enable the engineer to make a fairly easy assessment of the required width of opening by taking into account only the motorised held-up traffic ignoring the animal drawn and cycles. The graph of Figure-II has been prepared between motorised held-up traffic and the total time of closure per day. This graph indicates the following:-

i) For the portion surrounded by the ordinate and the first curve which starts from 260 passenger car units (PCU) of motorised held-up traffic and ends at 150 minutes total time of closure per day, a minimum of 16 ft.width gate opening is required.

ii) For the portion covered between the first curve and the second curve which starts from 1300 motorised held-up PCUs and ends at 300 minutes total time of closure, a minimum of gate opening of 24 ft. is required.

iii) For the portion covered between the second curve and the third curve (1300 PCU to 4000 PCU) a minimum gate width of 32 ft. is required.

iv) Similarly for the portion between third curve and the fourth curve involving upto 600 minutes of time closure and 10,000 PCUs of motorised traffic, a minimum gate opening of 48 ft.is required.

v) Beyond this, in the entire shaded portion of the graph, grade separation in the shape of an over or under bridge is required.

3. IDENTIFICATION AND ANALYSIS OF THE PROBLEM

The problem has also been identified from an economic point of view i.e. the assessment of the time value lost by the user of an automobile transport even after ignoring the non-motorized traffic.

Practical studies have indicated that the motorized road users, besides frustration and inconvenience to them, cause the following economic losses to the society by coming to halt at a level crossing:-

i) Deceleration cost.
ii) Cost of idle running of the engine.
iii) Acceleration cost.
iv) Cost of wear and tear of vehicles involved in deceleration and acceleration.
v) Time value of road users during stoppages.

The cost of the loss to society incurred through the railways has also been ignored. These studies undertaken by the Highway Department since 1972 indicate that the following social costs are incurred by the three main types of motorized vehicles on the road at each stoppage at a level crossing, on the basis of base year prices of 1970:-

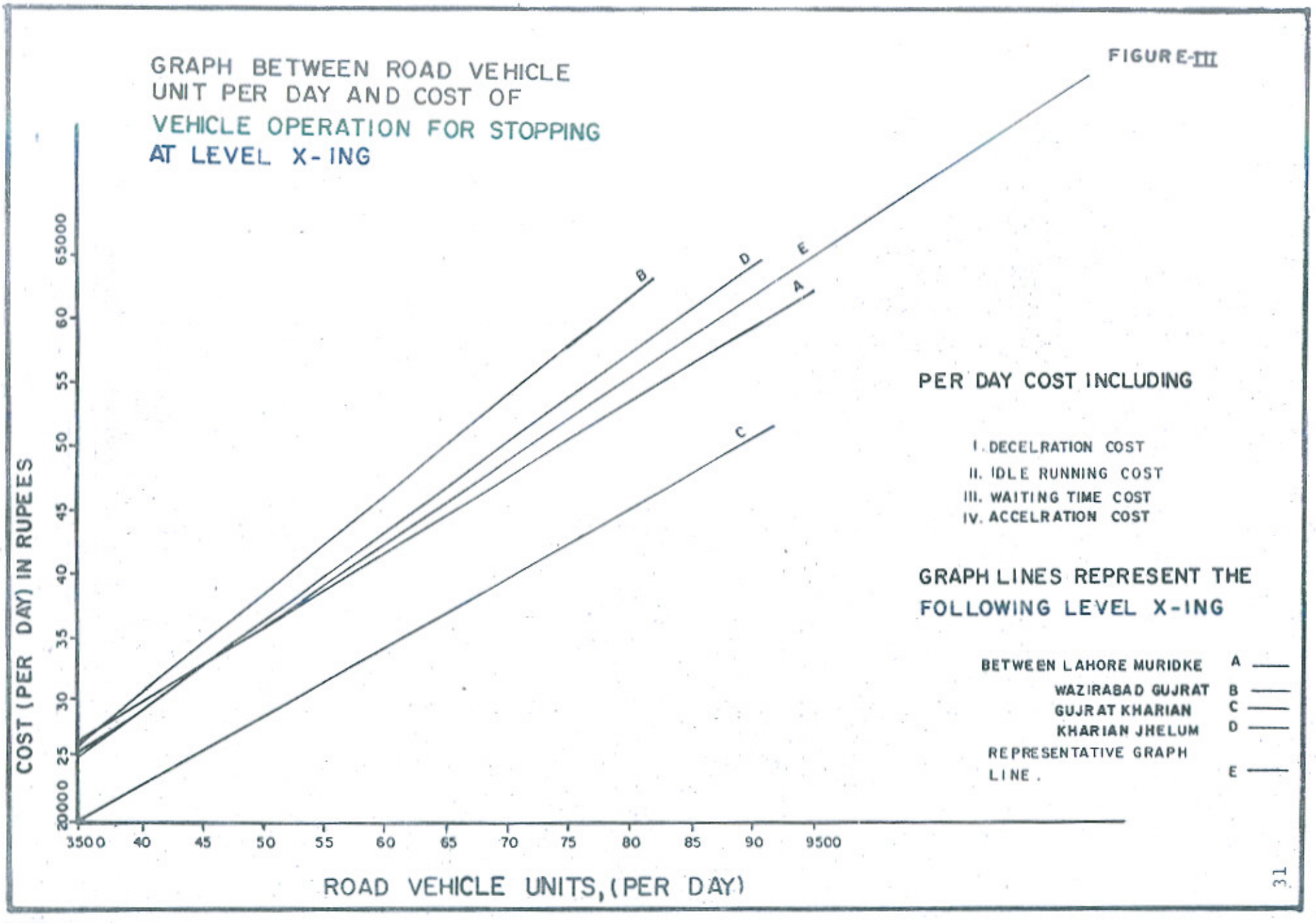
Truck	Rs. 1.20
Bus	Rs. 2.95
Car.	Rs. 1.34

Based on the average daily traffic and the percentages of various modes of motorised traffic, a graph has been completed as shown in Figure-III which shows the social cost per day at four sample level crossings on the G.T.Road as ordinate and the number of road vehicle units per day as abscissa. This graph is a very useful tool for the engineer and economist as it enables them to calculate the national loss at any given level crossing. From this graph it has been reduced that even if the cost of construction of a grade separation (over or under bridge) in place of an existing level crossing is Rs.one crore, the same is recovered back to the national economy in only one year. As the design life of a grade separation struc-

ROAD VEHICLE UNITS, (PER DAY)

FIGURE-III

GRAPH BETWEEN ROAD VEHICLE UNIT PER DAY AND COST OF VEHICLE OPERATION FOR STOPPING AT LEVEL X-ING



PER DAY COST INCLUDING

I. DECELRATION COST
II. IDLE RUNNING COST
III. WAITING TIME COST
IV. ACCELRATION COST

GRAPH LINES REPRESENT THE FOLLOWING LEVEL X-ING

BETWEEN LAHORE MURIDKE — A
WAZIRABAD GUJRAT — B
GUJRAT KHARIAN — C
KHARIAN JHELUM — D
REPRESENTATIVE GRAPH LINE. — E

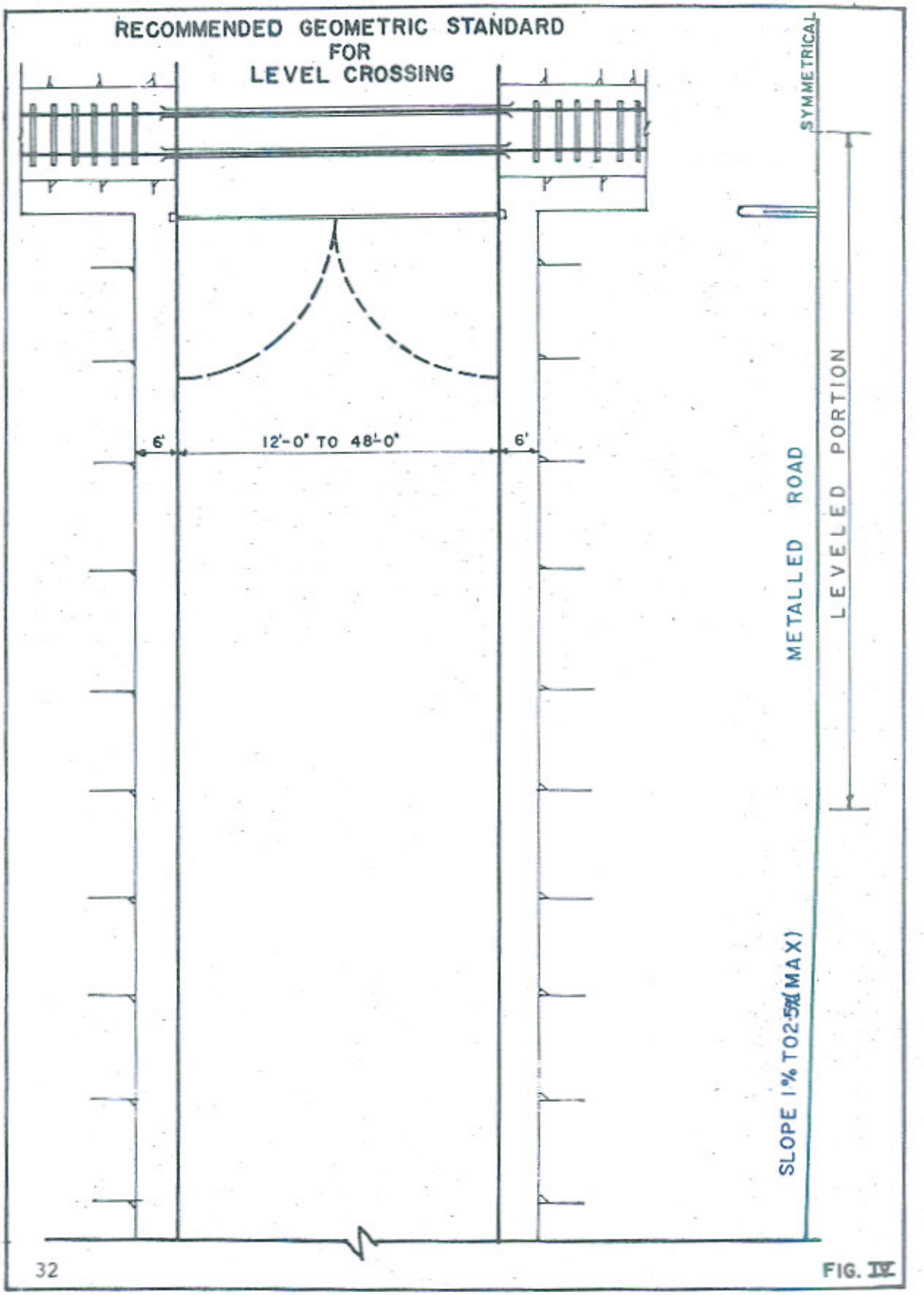

RECOMMENDED GEOMETRIC STANDARD
FOR
LEVEL CROSSING
SYMMETRICAL
6'
12'-0" TO 48'-0"
6'
METALLED ROAD
LEVELED PORTION
SLOPE 1% TO 2.5% (MAX)

FIG. IV

ture is taken atleast at 20-years, and the road traffic is increasing at a compound rate of 7% P.A.,the economic return to the nation in case of construction of a grade separation has been calculated in Table-I appended with this paper. It is interesting to note that even after depreciating the future cost savings at 14%, the benefit cost ratio is as high as 10.63. It is, therefore, high time that grade separations in the shape of over / under bridges are undertaken on the basis of economic rating of all level crossings in the country. Till such time that the concerned departments cannot afford the construction of the over/under bridges, there is un-deniable need for immediately improving the lot of existing level corssings which are far from satisfactory. It is here that we should devote ourselves to improving their standards. Accordingly a recommendation has been made in the form of Figure-IV, appended with this paper.This depicts the broad specifications for various types of level crossings.

4. SPECIFICATIONS AND GEOMETRICS

As the geometrics of the approach roads of the level corssing rather than the plan and profile of the railway are mostly responsible for causing accidents at level crossings, minimum geometric standards for various classes of level crossings are recommended in Figure-IV.

The prescription of specifications for various types of level crossings including geometrics have of necessity to be based on the road traffic volume and type.

Though the level crossings are meant for yielding right of way to the road traffic, the upto date specifications and classifications made by the Pakistan Railways are not in consonance with the volume or type of road traffic. The geometrics laid down in the Railways Engineering Circular No.2 dated 11.6.1915 and afterwards are very much out of date now. Against the maximum laden weight of 3 ton lorry prevalent at that time with a maximum length of 18 ft. we have semi-trailer combination units of 50 ft. length plying on our roads to-day with gross laden weights of upto 70 tons. The recommended geometrics for

various types of level crossing as shown in Figure-IV are strongly recommended to be adopted to reduce accidents and increase dispersal capacities of road traffic at the intersection points with the railways.

Out of the total 5386 number of level crossings in the country 1169 i.e. 21.7% only are manned and the 4217 or 78.3% are un-manned. Therefore, after prescribing specifications for the manned level crossings, the unmanned level crossings deserve great attention, the later being the main scenes of accidents.

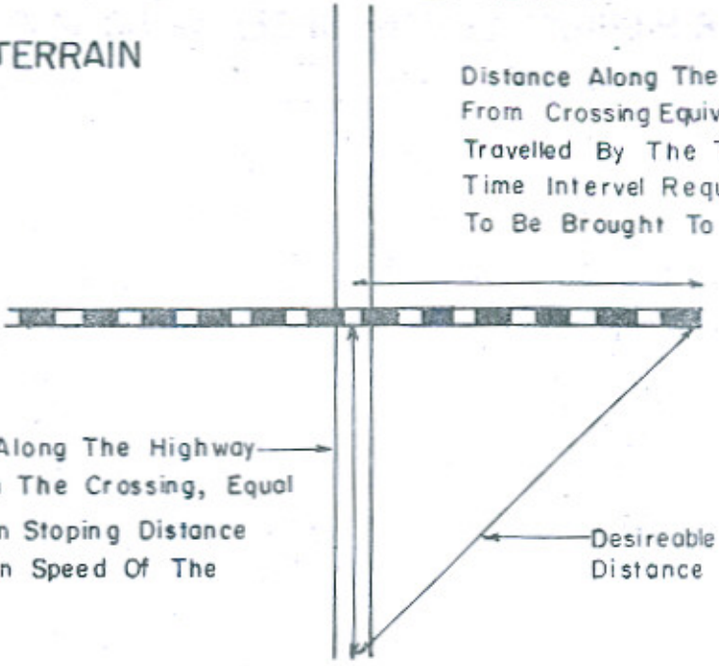
5. UNMANNED LEVEL CROSSING

No wonder that the number of casualties at the sites of unmanned level crossings exceed those of the manned level crossings by 50% to 1100%, which is a proof of the fact that unmanned level crossings are virtual death traps in our country. At unmanned level crossings, the geometrics and specifications of the level crossing and their road approaches are of greater significance than at the manned level crossings. As these level crossings are without signals and gates, the sight distance is of primary consideration at these sites. The specifications of the unmanned level crossings together with their rail and road approaches need immediate revision to reduce the incidence of accidents. While the subject is worthy of deeper study, preliminary thinking has been given to it and it is believed that the condition at a railway level crossing is comparable to that of interesecting highways where a corner sight triangle must be kept clear of obstructions. The desirable corner sight distance arrangement should be such that a vehicle driver on the road approaching the grade crossing is able to see a train at such a distance that if it proceeded without slowing down, it would reach the crossing at about the time that the highway vehicle can be brought to a stop in advance of the crossing. To satisfy this condition, two sides of the minimum sight triangle are: a distance along the highway, measured from the crossing, corresponding to the minimum stopping distance for the design speed of the highway, and a distance along the track, measured from the crossing equivalent to the distance travelled by the train during the time interval required for the highway vehicle

FIGURE - V

UNMANNED LEVEL CROSSING
MIN. SIGHT DISTANCES REQUIRED

CASE-I
FOR FLAT TERRAIN



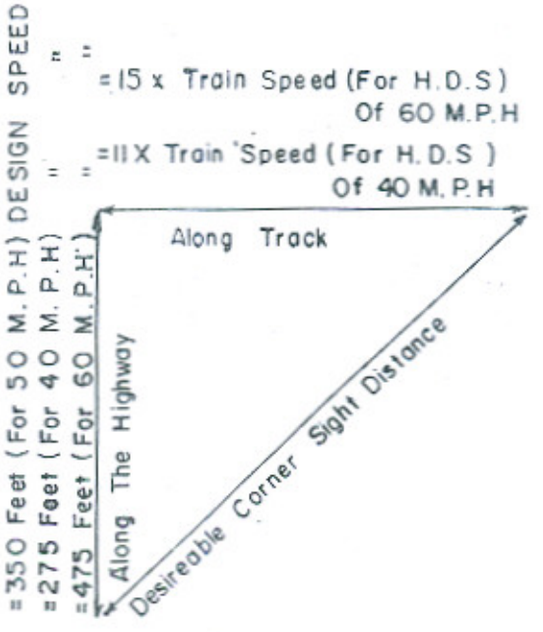
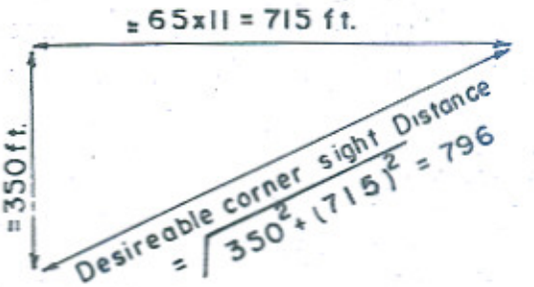
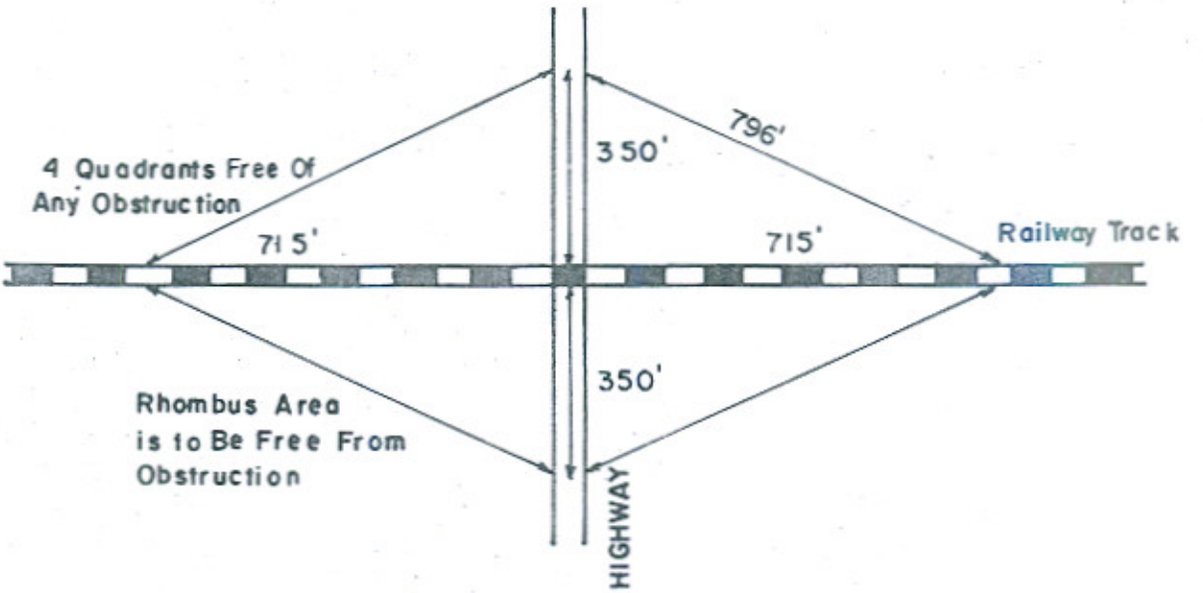


FIGURE-VI

FOR HIGHWAY DESIGN SPEED = 50 M.P.H
& TRAIN SPEED = 65 M.P.H

CASE-I
SOLVED EXAMPLE





to be brought to a stop. For a highway design speed of 40 mph (65 Km PH) the distance along the track in feet should be not less than 11 times the train speed in miles per hour, and for a highway design speed of 60 mph. (100 Km PH) about 15 times the train speed. Corner sight distances of this order in all four quandrants are desirable at any unmanned level crossing not controlled by signals or gates.

The attainment of these clear sight distances is particularly easy in a flat and open terrain as mostly obtaining in Pakistan. These recommendations have been depicted graphically in Figure-V. Actually solved examples have also been drawn ou r for a highway design speed of 50 mph and the train speed of 65 mph. Figure-VI is for a flat terrain country and Figure-VII is for a terrain other than flat. Also on Figure-VII is given the minimum sight distance required when traffic is controlled by STOP signs at a level crossing. This situation is applicable to unmanned level crossings over railway lines in hilly areas. Figure-VIII sketches out the distance required by a road vehicle to cross 2 tracks of railway line from a stopped position.

These standards are in line with the geometric standards prescribed by the American Association of State Highway and Transport Officials. While recommending these the traffic capacity of the lane width concept and the overall permissible length of vehicles have been kept in view Also considerations have been given to the steepest gradient which animals and animal drawn vehicles can encounter without difficulty. Minimum gradient and cross levels for drainage have also been kept in view.

The geometrics of a highway and a structure which entail the over crossing or under crossing of a railway are substantially the same as for a highway grade separation without ramps. The geometric design of a highway at a railway level crossing involves the elements of alignment, profile, sight distance, and cross section. The requirements may vary somewhat with the type of protective devices used. Where signs are the only means of protection, the highway should cross the railroad at or nearly at right angles. Even with signals or gates small

intersection angles should be avoided. Regardless of the type of control, the roadway gradient should be flat at or adjacent to the railway crossing to permit vehicles to stop when necessary and then proceed across without difficulty. The protective device should be clearly visible at a distance along the highway at least equal to and preferably greater than the stopping sight distances recommended below. In some cases, it may be necessary to elevate a device or shift it laterally from its customary position to make it visible at an adequate distance:

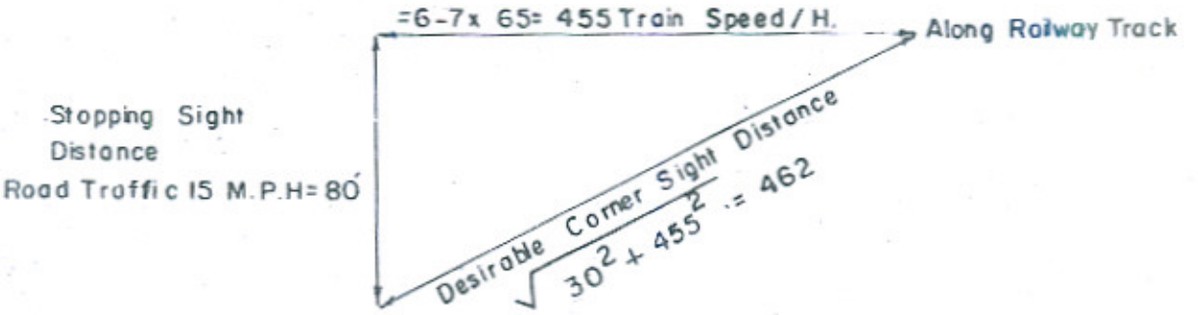
Road Design speed, mph.	30	40	50	60	65	70	75	80
Minimum stopping sight distance, feet.	200	275	350	475	550	600	675	750

However, design speeds of 75 and 80 mph are applicable only to highways with full control of access. Grade separations of rail and road traffic are presumed for such design speeds. Stopping sight distance is measured from the driver's eye at 3.75 ft. above the road surface to the top of an object 6 inches high on the road surface.

In case of an unmanned level crossing where stop sign has been installed as a protective measure, the driver of a stopped vehicle should be able to see enough of the railway to be able to cross it before a train reaches the crossing, even though the train may come into view immediately after the vehicle starts to cross. The length of the railway in view on each side of the crossing must be greater than the product of the train speed and the time necessary for the stopped vehicle to start and cross the railway track. The required sight distance along the railroad may be determined in the same manner as for a stopped vehicle to cross a preference highway. For vehicles to cross two tracks from a stopped position, with the front of the vehicle 15 feet from the closest rail, sight distances along the railway in feet should be equivalent to not less than 13.5 to 17.5 times the train speed in miles per hour for the SU (Single Unit) and WB-50 design vehicles, respectively. A distance equal to 10 times the train speed is applicable to the P vehicle, but

FIGURE-VII

CASE. II
FOR TERRAIN OTHER THAN FLAT

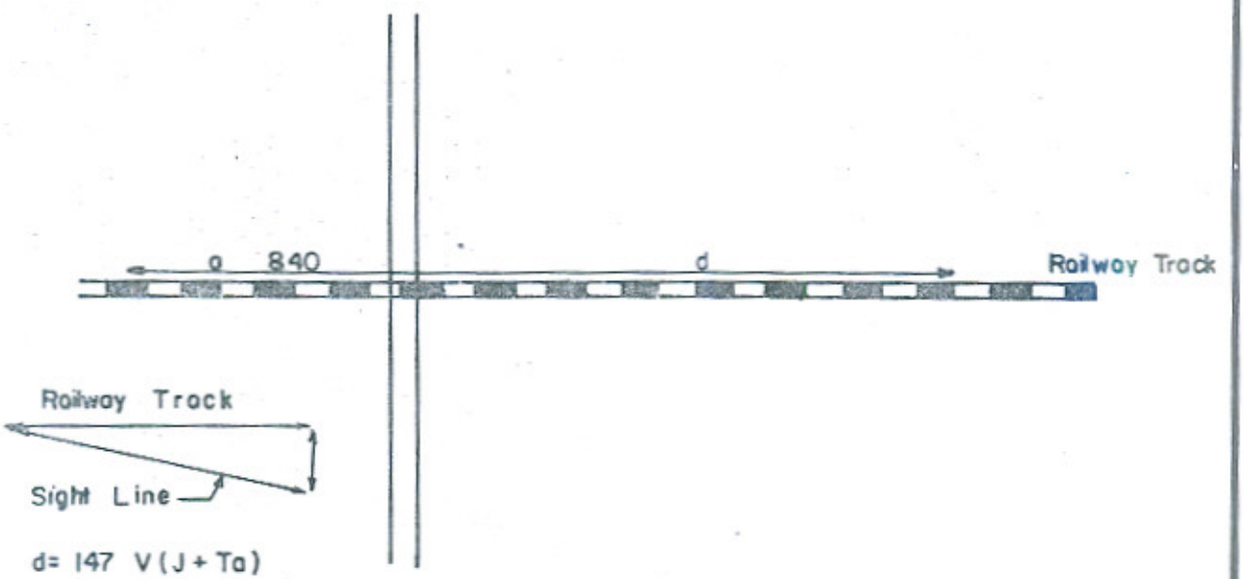


Minimum Sight Tringle For Case. II

CASE. III

AT AN INTERSECTION WHERE TRAFFIC IS CONTROLLED BY STOP SIGNS

I) For Single Track Crossing.



d= 147 V(J+Ta)

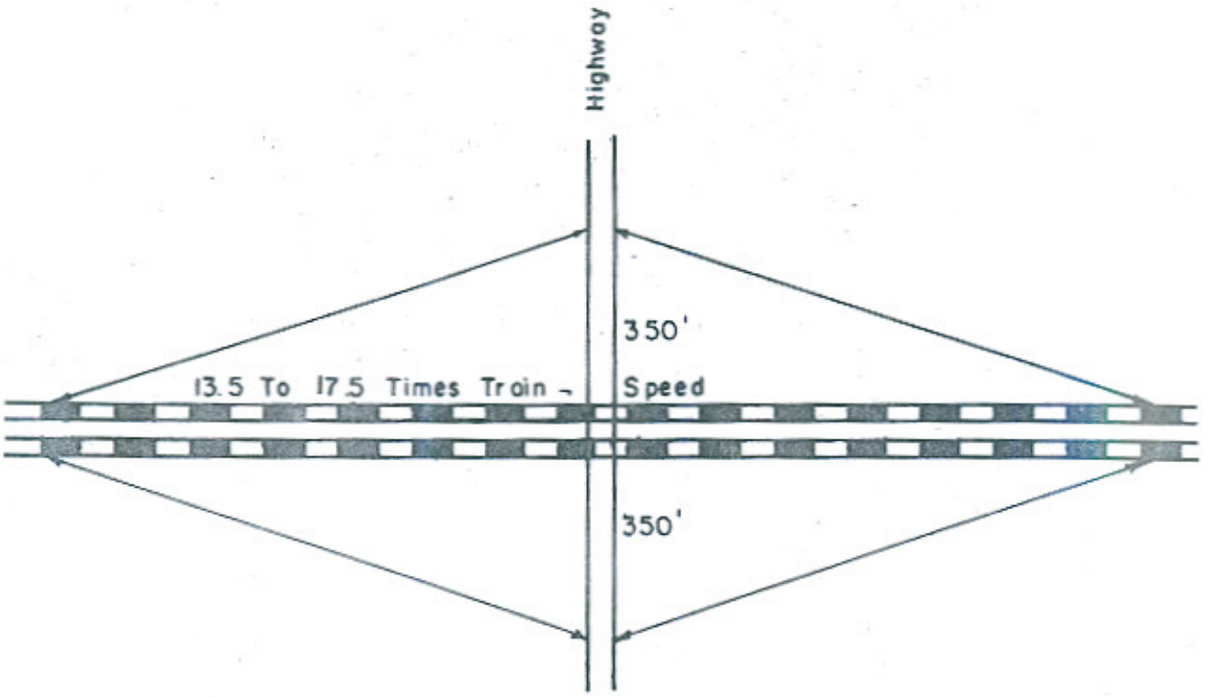
V= Speed Of Train in M.P.H= 65 M.P.H

J= Perception Time + Time Required To Shift To First Gear = 3 Seconds.

Ta= Time Required To Accelerate & To Clear The Track By The Vehicle = 3 Seconds.

FIGURE VIII

DISTANCE REQUIRED BY A ROAD VEHICLE TO CROSS TWO TRACKS FROM A STOPPED POSITION



design based on this vehicle is not recommended as almost all highways will have sufficient tracks or lanes to control the design i.e. S.U. and WB-50 vehicles. See Figure VII.

The highway travelled way at a railway crossing should be constructed for a suitable length with all-weather surfacing. Full stabilized or surfaced shoulders at least 6 ft. and preferably 12 feet wide, should be provided to the approaches of the crossing.

6. STATUTORY PROVISIONS

When railways were built in this part of the Sub-continent in the later half of the 19th Century, the Railways Act 1890 made it a statutory liability of the Railways to meet the cost of level crossing, road over bridges and under bridges at the time of the construction of a Railway-line or at any time thereafter, as laid down in para 1117 of the State Railway General Code Vol.I.

The then existing roads and paths were cut-across. As the right-of-way of the road user could not be denied to them under natural law and the law of the country, the railways made clear provision in their law for providing level crossings, road over bridges and under bridges as may be demanded by a prevalent situation. The problem therefore is of historical record and limited to the fact whether any road or path existed before the lay-out of the Railways or not. The level crossings therefore, can be categorized as:-

i) Those sites where roads and paths existed before the lay-out of the railways, and

ii) Those necessitated after the layout of the railways.

The 5386 existing level crossings on the Pakistan Railway should, therefore, be categorized in the above two categories, for purpose of apportioning the cost of improvements, required now on account of rail and road traffic conditions.

7. SUGGESTIONS

1) Where-ever the rail or road traffic or a combination thereof has crossed the curve line of Fig: I or social costs shown in Figure-III economically justify, a grade separation between the Rail and Road Traffic should be constructed in accordance with para 1117 of the State Railway General Code Vol. I. Cases of site shiftings due to ROW restrictions or high acquisition cost should also be categorized here.

2) Where a grade separation is required for similar reasons but no road or path existed at the time of laying down of the railways, the project should be financed by the Road Authority in accordance with para 1117 to 1122 of the State Railway General Code Vol: I.

3) The cost of improvement of an existing level crossing should be borne by the Pakistan Railways in accordance with the legal provisions to cater for the projected road traffic and in accordance with the required geometrics of the Road Authority.

4) Where a level crossing is necessitated now by a Road Authority and no path or road existed at the time of laying down the railways, the entire lay out should be financed by the Road Authority.

8. IMPLEMENTATIONS

The recommendations should be backed up with necessary legal force and implemented through an annual phased programme, to be supervised by a committee of experts constituted with nominees from the concerned Departments.

We judge overselves by what we feel capable of doing while others judge us by what we have already done.

Join the Gas Club

By
Khalid Faruq
Chief Engineer
Irrigation Research Institute, Lahore

The price of petrol has been soaring and soaring over the last 10 years or so. In the year 1972 the petrol used to cost a mere 5.25 rupees per gallon (regular variety) but it has been shooting up consistently and there have been about 10 upward jolts over this period. At each rise one thought that this was the limit and further rise was not conceivable. Yet defying all calculations and anticipations the prices have been mounting and have reached the staggering figure of Rs.20.27 per gallon of regular & Rs.23.64 of super variety. Anything is now possible in this realm and the portents are that the international situation will take us to still dizzier heights. A projection of future oil prices worked out recently by some experts anticipate a further rise to 3 times the present prices over the next decade. Now what to do and how to keep the old buggy moving and also keep the wolf from the door. This is the question in the minds and on the lips of every person with a reasonable level of income (those lucky ones who run on on-account charges such as masters and employees of commercial concerns of autonomous and semi autonomous bodies have of course no worry on this account). The most seriously affected group is the fixed income group whose income does not automatically follow the steep curve of price rise. In the above category the Government servants as a class are the most seriously hit. One solution that suggests itself these days is the use of LPG (liquified petroleum gas) for running ones car. LPG is not compressed Sui Gas but is the bye product of Oil wells and refineries and consists mainly of Propane and Butane. Despite the repeated notes of warning by the concerned Gas Company that they cater only for domestic use and do not have the capacity to fulfill the ever rising needs of vehicles and that the consumers should desist from using the gas for the latter purpose, the idea is picking up and one comes across so many advertisement offering to convert your car on to LPG. In fact alongwith the warnings there is a hopeful note that the introduc-

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tion of a system for running vehicles on LPG is under consideration.

In his inaugural speech in the National Symposium of Energy Conservation, the Additional Secretary incharge of Ministry of Petroleum and Natural Resources stated that 'The production of liquid petroleum gas from indigenous sources is being increased three times over the next 18 months to provide the consumers with an alternate fuel for kerosene. Compressed natural gas as fuel for Buses, Trucks and Automobiles is being introduced shortly on pilot scale'. The above position was reiterated in a press conference by the same authority reported in the Press in May, 1980.

There is much myth and truth afloat for and against the use of LPG. People are anxious to know facts about this venture, to enable them to make the right decision. For the interest of our readers we produce some relevant information on this subject which will answer many of their questions. In doing so we will also be quoting from relevant questions and answers from an article appearing in the Magazine Popular Mechanics of September, 1979.

The conversion to LPG entails first of all fixing a Gas Kit in your car. Gas Kits of American, English and Italian origin are the most common in the market. These are marketed in different sizes for cars of different displacements in CCs. It is advisable to use the kit matching the size of your engine. The kits are designed to work on 12V batteries and any attempt to change over to 6V by replacing the original solenoids by locally wound coils is bound to spoil the kit. Since warming up of the liquid gas is achieved by circulating the radiator water through the kit assembly, the kits are not suitable for air cooled engines. The current prices of the kits are upwards of Rs.2300, the Italian being in the lowest price range. The gratifying feature of installing a gas kit is that your old petrol fuel system still remains intact and you can switch over to either system on command by simply operating a switch on your dash board. The gas kit includes solenoid switches which can close or open gas/petrol electrically (or sometimes mechanically).

The accessories for fixing the gas kit, such as copper and rubber/plastic tubing, clamps, T's, nozzles, etc. vary with the type of kit & the mode of its connection with the fuel system. The gas can be introduced into the carburetor by overhead fitting on the top of the carburetor or by side injection into the carburetor by suitably modifying it. The latter process is cheaper and the accessories together with carburetor modification may cost about Rs.300/-. For the over head system the cost of accessories and modifications may be Rs.550/- or so. As regards modification of the carburetor, some milling shops have specialised in the job and do the needful in about 2-3 hours at a cost of about Rs.100/- (included in the above quoted figures).

There are certain shops in the market which cater for most of the needs of a gas kit and almost all the accessories are readily available at one place. The system ends up in your luggage boot in a flexible tube designed to withstand high pressure of the gas. At the loose end of this tube you fix a connector (described later) through which you connect the engine system to the gas cylinder. The fitting charges of the gas kit (labour) varies between Rs.200 & Rs.300.

The procurement of cylinder and the connector piece is the next step, which is a real problem these days. The gas company, due to shortage of gas (primarily on account of a temporary shut down of their plant at Dhulian) has stopped giving any new connections. (Obtaining a cylinder from the Company means entering into an agreement on payment of Rs.250 as security or Rs.575 as cost of cylinder). It is understood that Connectors (usually local made) and Cylinders are offered by unauthorised persons at black market prices. The replacement cost of loaded cylinder containing 11.8 kg of LPG at a pressure of 150-170 lbs/sq. inch, is currently Rs.27/-. Owing to the non-production of gas from Dhulian plant near Pindi, an extra charge of Rs.5/- per cylinder as carriage charges to up-country from Karachi is also currently being added, making the total cost per cylinder to the consumer as Rs.32. Hopefully this is a temporary phase and the extra carriage charges will be eliminated as soon as the Dhulian Plant recommences production, which it is said will be

in December this year. Another Company operating under a different trade name has a few distribution points and that also in only a few major cities. This variety of gas besides being scarce in the city may not be available en-route on long journeys. As a rough guide it may be stated that as far as the car mileage is concerned one cylinder is equivalent to about 4 Gallons of petrol. So that if your car normally does 25 MPG on petrol it should run over a 100 miles in one cylinder of gas. At the current price of Rs 4/46 per litre of regular petrol and Rs.5.20 per litre of super variety, cost of a gallon comes to Rs. 20.27 and 23.64 respectively. (4.546 litres= one gallon). The reader can from these figures easily calculate for himself the economy factor.

The system of distribution of gas in vogue is that the gas company has established several depots (which receive supply in bulk directly from the producers) and distribution points (which receive their supplies from the depots) in nearly all the major towns of the country. At their depots/distribution points you hand over the empty cylinder and receive a loaded one on the payment of the price fixed by the company (which is currently Rs.27/-+ Rs.5/-).

During periods of shortage the production of the agreement document with the gas company is insisted upon before supplying the loaded cylinder and an entry to that effect is also made on the document to keep a check over the supply.

The user of the gas soon realises that he cannot do with just one cylinder. He has to have 2 cylinders so that as soon as one cylinder is exhausted he can immediately switch over to the next one. Otherwise the user will have to switch over to petrol (a painful happening when you are used to gas) till he finds the new loaded cylinder (which is sometimes not available for some days). If there are 2 cylinders then on the exhaustion of one, he can forthwith connect the loaded cylinder and have the empty one replaced at leisure. To avoid rolling of the cylinder in your luggage boot (which in addition to being noisy may damage your fittings) it is advisable to make a simple wooden or wire cradle to hold the cylinder. In addition the

cylinder can also be strapped on to the cradle by using canvas belts (cheaply available from dealers of tonga harnesses). The connection of a new cylinder with the engine is a simple affair. The gas company along with the cylinder also provides you a connector piece, the current company price of which is Rs.125. As described earlier the connector is permanently fitted on to the flexible pressure tube which is inturn connected to gas circuit of your engine. (It may please be noted that there are two types of connectors one for domestic use and the other for use on vehicles, and one cannot be used in place of the other). The connector is fixed on to the new cylinder by simply pushing it against the opening of the cylinder and turning a knob on the connector through 180°. The connector performs 2 functions. While being fitted on to the cylinder it pushes open the valve in the cylinder, thus establishing the flow of the gas from the cylinder to the engine through the flexible pressure tube. When disconnected from the cylinder (by turning the same knob now backwards by 180°), the connector does not allow the compressed gases in the engine circuit to escape back to the atmosphere, as it has a built in valve for this purpose.

The gas kits do not contain any meter to indicate the residual gas in your cylinder at any time. You have to learn by experience as to how many miles your car runs on one cylinder. Thereafter you can monitor the use of gas by every time noting down the reading on the milometer when a new cylinder is connected.

When switching over from gas to petrol (which may be due to exhaustion of gas cylinder or some trouble in initial morning starting of the car), the carburetor will be empty of petrol and the running of car cannot be established till it is filled up. This may require a lot of cranking of the engine on battery before the carburetor is filled up, and in the process you may have run down your battery (most of the Japanese and American cars have the mechanical type of fuel pump which is coupled mechanically with the engine). Moreover when you are running on gas you are apt to forget about your petrol so that your petrol tank may be empty and you may be cranking your engine in vain. Experience has shown that this dif-

ficulty can be overcome by installing a battery operated fuel pump which takes a nominal current and works with a ticking sound which is audible to the driver. It stops ticking when the carburator is full and the driver atonce knows that he can now start his car on petrol. On the other hand if there is no petrol in the tank the pump will go on ticking without coming to a stop and the driver will know that it is no use cranking the engine. The Electric fuel pumps which were a feature of most of the english cars are available brand new in the market at a cost of about Rs.500 & old ones with junk dealers in Bilal Ganj at a reasonable price. This electrical pump can be fixed in series with the mechanical pump without affecting the working of the latter. The electric pump should be operated by a push button switch on the dash board, to be operated only to fill up the empty carburator whereafter the mechanical pump will automatically take over as in the case of normal running. Switching over from petrol to gas is accomplished in 2 stages. If you switch over directly from petrol to gas, the carburetor bowl will already be full of petrol and the introduction of gas will cause over charging by both the fuels resulting in stoppage of the engine. To obviate this situation, the manufacturers have provided a neutral position on the change over switch on your dash board where the engine is disconnected from both the fuels. In some gas kits the operations of disconnection of gas and the switching on of petrol are through 2 independent switches. You allow to run the car for some time with gas disconnected or at neutral position of the switch as the case may be and within about a minute or so the carburetor bowl will be exhausted of petrol and the engine will start 'missing'. Now you put your switch on 'gas' and the change over will be smooth.

Now we quote some interesting & relevant portions of a question and answer article on the subject appearing in the magazine "Popular Mechanics" of September 1979:-

> "I converted my 1971 Cougar to propane in 1973 at the time of the last gasoline shortage, Price says, I wanted an option and I found it in propane.

"Price's Cougar had 50,000 miles on the odometer when he converted to propane. The day I saw the car in the driveway of his home in Fanwood, J.J., it had registered 110,673 miles and was still going strong".

Q: Isn't : propane tank likely to explode if your car is hit in the rear, and isn't propane likely to leak and catch fire if the car rolls over?

Ans: Not if good-quality equipment is used and the installation is done correctly. The tank is positioned well inside the trunk, up on the deck where the spare tire normally sits. If there is a rear-ender, the gasoline tank will 'go' before the propane tank. Furthermore, in the event of fire, the propane tank, the walls of which are three times thicker than those of a gasoline tank, is practically impregnable. And propane won't leak in a roller-over accident since there are check valves that automatically seal lines.

Q: Where do you keep the spare tire now?

Ans: On the floor of the trunk it does take up laugage space, but this is something you have to accept.

Q: Isn't the car's original fuel system removed when you add a propane system?

Ans: No. It stays in the car, giving me a dual fuel system. The engine has the advantage of being operated on either gasoline or propane fuel.

When changing from gasoline to propane, a control cable on the dash is moved halfway in. This closes a solenoid in the gasoline line and stops gasoline flow to the carburetor. The engine is now running on gasoline left in the float bowl of the carburetor. When this gasoline is used up and the engine falters slightly, the cable is then moved all the way in. This closes an air valve in the mixer and opens a vacuum operated filter-fuel lock in the propane system. Liquid propane flows through a vaporizer regulator and is drawn upon engine demand, to the mixer. The mixer is mounted adjacent to the car-

buretor and blends the proper amount of propane with air flowing to the engine. This air/propane mixture is fed through the throat of the carburetor into the engine.

When a fuel dealer pumps propane into the tank in my trunk, it is pumped in under a pressure of about 150 p.s.i. This pressure is maintained to keep the propane in a liquid state in the tank. The converter depressurizes and applies heat to the propane by engine coolant diverted to the converter (at the heater hose). The combination of depressurization and heat instantly transforms the liquid to vapor.

When changing from propane to gasoline, the control on the dash is moved all the way out. This opens the gasoline shut off and air valve in the mixer. It also closes the vacuum operated, filter fuel lock in the propane line. The float bowl of the carburetor fills with gasoline which is the fuel the engine now uses.

Q: Is there ever a time when the two fuels, propane and gasoline, can mix together? If so, will the car blow up?

Ans: The only time the two fuels can mix is when I switch from gasoline to propane. Switching to run the engine on gasoline instead of propane, or on propane instead of gasoline, can be done as I'm driving, as well as when the engine is turned off.

When switching over to gasoline from propane, there is no chance of mixing fuels. I shut off the propane and turn on the gasoline by pulling the control handle which opens the air valve and gasoline shutoff. It takes a second or so for gasoline to fill the carburetor fuel bowl and begin flowing into the cylinders. The amount of propane left in the fuel system at the time of propane shutoff is just enough to keep the car running until the flow of gasoline begins.

However, before switching to propane from gasoline, I have to see that gasoline left in the carburetor bowl is consumed to prevent mixing the two fuels.

I do this by pushing the control halfway,which shuts off the flow of gasoline to the carburetor,but does not open the propane port in the converter. The engine runs on the gasoline left in the carburetor bowl. When the engine begins to lose power as gasoline runs out, I push the control handle all the way in to open the propane filter-fuel lock in the converter to supply propane.

I learned from experience what can happen if the two fuels mix. I forgot the halfway position and pushed the control all the way to switch from gasoline to propane. No, the car didn't blow up. The engine simply stalled and wouldn't restart, because the mixture of gasoline and propane flooded the cylinders. I had to move the control handle halfway in and hold the accelerator pedal to the floor while cranking the engine to clear the cylinders. After driving a short distance, I switched to propane, using the correct procedure.

Q: What about emissions? Does propane pollute the air?

Ans: A lot less than gasoline. Propane emits meager hydrocarbons, since 99 percent of propane is burned in the cylinders. Hydrocarbon is unburned fuel, Furthermore,with propane the engine can be adjusted so it emits only 1.0 to 1.5 percent carbon monoxide (CO) without affecting performance.

As for oxides of nitrogen (NOx), they too are very low.

Q: How does the engine perform on propane?

Ans: Much better than on gasoline. Propane is a fuel of approximately 110 octane. My pontiac 301-cu-in-engine emits no spark knock on heavy acceleration, as it sometimes does on gasoline.

Q: Are there harmful effects on the engine?

Ans: None whatsoever, in fact, I've been told to expect longer engine life. Since propane in the engine does not form drops of liquid (like gasoline) to wash

down cylinder walls and dilute motor oil,oil-change intervals may be extended. I can expect longer life from sparkplugs, too, since propane leaves no carbon. The engine is kept clean.

I am so convinced of its beneficial effects that I use propane as my main fuel and keep gasoline in reserve. In doing this, however, I run the engine every couple of weeks on gasoline to prevent rubber parts in the carburetor from drying out, and I will make sure each tank of gasoline is consumed and replenished at least once every three months.

(while the articale was under print, the proces of petrol have registered yet another upward shift to Rs. 5 & Rs.5.53 per litre - Rs. 22.73 & Rs.25.14 per gallon - of regular/super variety)

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The tallest office building in the world is Sear's Tower completed in 1974, the national head quarters of sears robuck & co., Chicago (U.S.A) with 110 stories, rising to 1,454 feet(the addition of two T.V antennae brought the total height to 1,559 feet). The cross area is 4.4 million squar feet (101 acres).The buildings population is 16,700 served by 103 elevators and 16 escalators. It has 16,000 windows.

Conjectures

By

KHALID FARUQ

One cannot reconcile with the idea of a 'conjecture' in such a definite and precise science as mathematics. It would however be interesting to know that a regular species of conjectures do exist even in mathematics, which are named after the great mathematicians who spelled them out. A 'conjecture' it may be stated is a proposition without a mathematical proof and is a challenge to the world either to prove it or to disprove it - either way it would bring name and fame to the person who does it. Such conjectures are a tribute to the amazing intuition of the mathematical geniuses who propose them.

There is for instance the Goldbach conjecture dating back to 1742, that every even number (except 2) can be expressed as the sum of two prime numbers (e.g. 24 = 17 + 7 etc). The proposition still stands unvitiated as well as unsupported. Neither it has been proved nor disproved, nor an even number has been produced which is not the sum of two prime numbers. A Russian Scientist working on this proposition was able to show in 1931 that each even number is the sum of not more than 300,000 prime numbers. Another Russian Scientist later on narrowed the gap to 'sum of not more than 4 prime numbers' and there the matter rests.

Similarly Fermat's conjecture is that there are no positive integer solutions to the equation $X^n + Y^n = Z^n$ for values of n greater than 2. (i.e. an integer solution of the type $3^2 + 4^2 = 5^2$ does not exist for values of n higher than 2). In fact in the year 1621 the mathematician made a remark about the above equation in the margin of a book which was under his study, that he had discovered a truly wonderful proof of the same, for which the margin in which he was writing did not provide enough space. It was quite some time after the death of

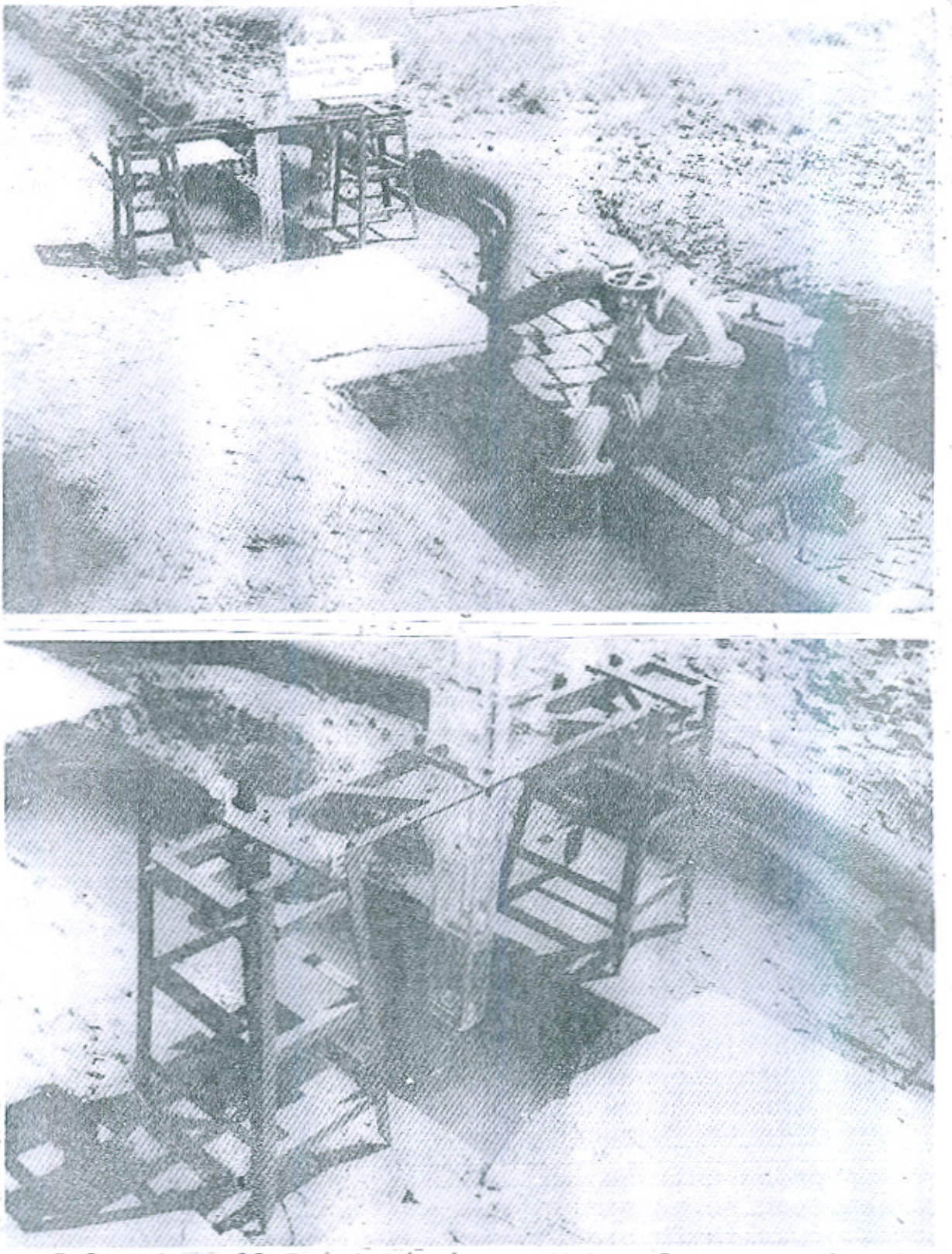
the mathematician that the above remark came to notice by chance and since then the mathematical world has been toiling in vain for 3 centuries to discover that wonderful proof which the mathematician had in mind. A reward of 100,000 German marks for providing a solution inspite of generating much interest failed to produce an answer. It has however been shown mathematically that the proposition holds good for each value of n upto 269, but no generalised proof is forthcoming.

We may refer to yet another problem in the same line. In any map drawn either on a flat surface or a globe, 4 colours always suffice to avoid confusion at the boundaries of the 'states'.

Try as you will, you can never devise an imaginary map (on a flat surface or a globe) which requires more than 4 colours for avoiding confusion at the boundaries of the States. The best that has been done is to show mathematically that not more than 5 colours are sufficient for the proposition, but the final break through has yet to come.

THE FASTEST CAMERA

The fastest camera in the world is the Imacon 600 manufactured by John Hadland (P.I) Ltd of England which is capable of 600 million photographs per second, with the maximum framing rate. Uses include laser, ballistic, detonic, plasma and corona research.



Saleem's Null Point Discharge Meter for measuring discharge of field Water Courses(Details Overleaf)

SALEEM's NULL POINT DISCHARGE METER

A special technique has been developed in Irrigation Research Institute to measure accurately the discharge in a running water course. This has its special application in the accurate measurement of conveyance losses in running water courses.

The technique is based on the principle that at the desired selected station the entire discharge is bye-passed with a pumping unit, passed through a water meter and then again discharged in the same water course at a distance of about 25 feet down stream as shown in the top photograph. The water lying in the water course between the two points, viz. the point where water is sucked and the point where it is re-discharged, is subjected to three states:

(i) the water in this section flows in the forward direction (with reduced velocity of course) if the pumped water is less than the total discharge in the water course.

(ii) it flows in the backward direction if the pumped water is more than the total incoming discharge

(iii) it is stationary if the pumped water is exactly the same as the incoming water in the water course.

To indicate accurately the Null point a special apparatus has been developed in the Institute, which has a very sensitive 'flapper' as shown in the bottom photograph. When the null point is attained, the meter reading in the water meter gives accurately the discharge flowing in the water course.

The pumping unit is mobile, handy and runs with a small diesel engine. A similar observation can be carried out at some suitable station down stream in the water course This will give the conveyance losses between these two stations. The apparatus thus works without altering the conditions in the water course.

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