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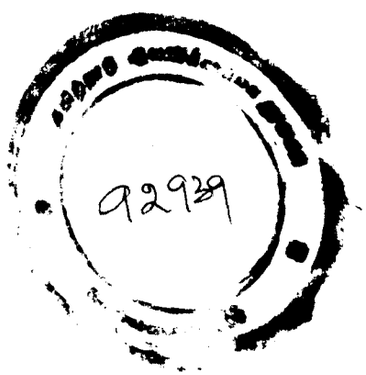


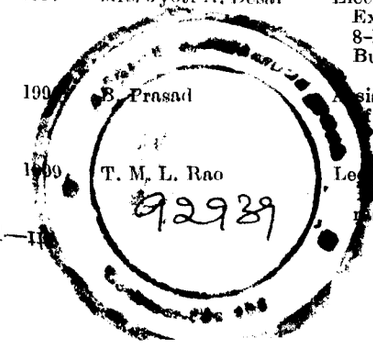
INDIAN ROADS CONGRESS

NOTICES AND ANNOUNCEMENTS

NEW ADMISSIONS

LIST OF MEMBERS OF THE INDIAN ROADS CONGRESS ENROLLED FROM 1—10—1955 TO 17—11—1955

Serial No.	*Roll No.*	*Name.*	*Address.*
1	1988	S. C. Bansal	District Engineer, P. W. D., **Mainpuri**, (Uttar Pradesh).
2	1989	V. Seshadri	Assistant Engineer, Highways, **Cannanore, N. Malabar**, (Madras State).
3	1990	T. S. Chandrasekhar	Assistant Engineer (T. B. P.), No. 317- Gandhinagar, **Bellary.**
4	1991	G. C. Venkateswara Rao	Assistant Engineer, Highways, Bridges Investigation, **Cuddapah** (Andhra State).
5	1992	D. K. Sinha	Assistant Engineer, P. W. D. Sectt., **Patna** (Bihar).
6	1993	M. Palaniswami	Junior Engineer, Highways, Taliparamba, Post Taliparamba, **North Malabar.**
7	1994	T. P. Kandasamy	P.A. to Superintending Engineer (H), Race Course Road, **Coimbatore.**
8	1995	Mohd. Ataur Rahman	Assistant Engineer, P. W. D., **P. O. Madhipura**, District Saharsa, (Bihar).
9	1996	A. P. Jain	Assistant Engineer, Central P.W.D., **Udhampur** (J. & K. State).
10	1997	Mrs. Jyoti A. Desai	Electrical Engineer, M/s. Associated Exports Imports Corporation, 8-B, Lall Bazar Street, Bikaneer Building, 2nd Floor, **Calcutta-1.**
11	199[illegible]	B. Prasad	[illegible]sistant Engineer, P. W. D., Office [illegible]f the Chief Engineer, B. & R., [illegible]atna (Bihar).
12	1999	T. M. L. Rao	Le[illegible]urer in Applied Mechanics, [illegible]ngineering College, **Morvi** (Saurashtra).



Serial No.	Roll No.	Name.	Address.
13	2000	A. Abdul Khader	Assistant Engineer, Highways, **Ariyalur**, Trichy District.
14	2001	A. Palayya	Assistant Instructor, Deptt. of Civil Engineering, College of Engineering, **Kakinada** (Andhra State).
15	2002	S. S. Gangopadhyayya	Subdivisional Officer, Development (Roads), **P.O. Tamluk**, District Midnapur (West Bengal).

ASSOCIATE MEMBER

1	61	M/s. Uttam Singh Dugal & Co. Ltd.	Engineers & Contractors, 11-Marina Arcade, **New Delhi**.

Paper No. 185

"GLOSSARY OF HIGHWAY ENGINEERING TERMS AND HINDI EQUIVALENTS"

By

THE SPECIFICATIONS & STANDARDS COMMITTEE OF THE INDIAN ROADS CONGRESS

[*Following precedent, the recommendations of the Specifications & Standards Committee on 'Glossary of Highway Engineering Terms' are published in the Journal. Members are requested to send their comments in writing by the 31st March 1956.*]

For purposes of easy reference, the terms of the Glossary have been grouped into eight Sections. Sections 1, 2 and sub-section 3.1 were presented to the Congress as Paper No. 146*. Sections 3.2 to 5.2 were published as Paper No. 170†, and comments of members invited. The present Paper deals with the following Sections:

SECTION 6. **Plant and Machinery**

SECTION 7. **Traffic**

7.1. General Terms

7.2. Signs and Directions

SECTION 8. **Miscellaneous**

Since the publication of the above mentioned two Papers a committee appointed by the Ministry of Education, Government of India, have compiled equivalents in the national language, Hindi, for all the terms included in the I. R. C. Glossary of Highway Engineering Terms. The Ministry of Education have now requested the Congress to give wide publicity to the Hindi equivalents and have asked for comments on their suitability. Accordingly, Hindi equivalents also have been given for Sections 6, 7 and 8. An appendix to this Paper contains the terms already published in Paper No. 146 and 170 and their Hindi equivalents.

* Journal of the Indian Roads Congress, Volume XIV-3, December 1949.

† Journal of the Indian Roads Congress, Volume XVIII-3, January 1954.

Members are requested to give their comments on the definitions of the terms now published, as well as on the suitability of the Hindi equivalents. If they have any other Hindi or widely current regional language terms to suggest in place of the equivalents published here, their suggestions will be most welcome. All comments and suggestions should reach the Secretary, Indian Roads Congress by the 31st March 1956.

To facilitate reference to published literature, as classified in libraries, Universal Decimal Classification numbers have been given, wherever possible.

The Use of terms given within backets is deprecated.

सयंत्र और मशीनरी

खंड—6

Definition No.	U. D. C. No.	TERM	DEFINITION
60.01		ANGLEDOZER * एंगिल डोज़र	A tractor on the front of which is mounted a suitable blade which can be set obliquely to the line of advance.
60.02		ASPHALT PLANT अस्फ़ाल्ट सयंत्र, अस्फ़ाल्ट प्लांट	A complete mechanical equipment for the processing of asphalt.
60.03	625.8.088	BATCHING PLANT बैचिंग प्लांट, स्वमापी संयत्र	The mechanical equipment for measuring, either by weight or volume, the quantities of different ingredients required to make up each complete charge of a mixer.
60.04	625.8.086	BULLDOZER ** बुल डोज़र	A tractor on the front of which is mounted, at right angles to the direction of advance of the machine, a wide blade of suitable shape, which can be raised or lowered.

* The equipment is used to push material to one side of the machine. The word "Angledozer" is also used for the equipment which, when mounted on a tractor, constitutes a complete machine of the type stated above.

** The equipment is used for pushing material forward. The word bulldozer is used for the equipment which, when mounted on a tractor constitutes a complete machine of the type stated above.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.05		BUSH HAMMER (१)सफ़ाई हथौड़ा, (२) बुश हैमर	1. A light percussive machine, usually driven by compressed air and held in hand, for removing the outer skin from concrete and the like, thus exposing the aggregate. 2. A tool used for giving a type of surface on stone masonary.
60.06		CAULDRON कढ़ाह	An open vessel for heating tar or bitumen.
60.07		CONCRETE FINISHER कंकरीट समकारक	A wide wooden or metal template, or flat band, which may be either manual or power operated, and used for the purpose of floating or smoothing off large concrete surfaces as a continuous operation. (*See Float, 60.19*)
60.08		CONCRETE PAVER कंकरीट पेवर	A concrete mixer capable of moving on crawler tracks or rails and provided with a boom and bucket for depositing the concrete in the required position for a pavement.
60.09		CORE DRILL गुल्ली, बरमा	A rotary apparatus used for extracting cylindrical specimens for tests.
60.10		CRANE क्रेन, ऊँटड़ो	A machine for hoisting, slewing and lowering heavy loads.
60.11		CRAWLER TRACK रिंगण पट्टी	A device, consisting of an endless chain of plates which bear upon the ground, used in place of wheels on vehicles or equipment, intended for traversing soft ground.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.12	625.8.088	CRUSHER दलित्र	A machine for breaking stone or similar material to suitable smaller sizes.
60.13		DRAG घाटा या हेंगा	A machine, usually dragged and used for scraping off and levelling irregularities during the construction or maintenance of roads. (*See Grader, 60.22*)
60.14		DRAGLINE * EXCAVATOR डोल खनित्र	A machine used principally for excavating below the level of the machine.
60.15		DUMPER डम्पर	A vehicle for transporting material, so designed as to be capable of discharging its load by forward tipping.
60.16	625.8.086	ELEVATING GRADER भरित्र	A machine equipped with a scrapper and elevating attachment to discharge the loosened material into vehicles for transport.
60.17		ELEVATOR उत्लाचित्र, उच्चालित्र	An appliance for raising material from one level to another by means of an endless belt or a chain of buckets passing over rotating drums or gearing.
60.18	625.8.087	EXCAVATOR ** खनित्र	A power operated digging machine, usually mounted on crawler tracks.
60.19		FLOAT गुरमाला, गुरमाला फेरना (*Contd*)	(a) A flat-faced wood or metal hand tool for spreading or smoothing mortar, mastic

* It consists of a bucket suspended by ropes and filled by being dragged towards the machine.

** It may be fitted with various attachments for different methods of excavation.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.19		FLOAT (*Contd.*) गुरमाला, गुरमाला फेरना	road materials or the like in plastic form. (*See Concrete Finisher 60.07*) (b) To produce a smooth surface on materials in plastic form.
60.20		GAUGE BOX माप बक्स	A receptacle for measuring materials by volume.
60.21		GRAB* ग्राह	An attachment, fitted to an excavator or crane, consisting of a split and hinged bucket suspended from a jib and fitted with interlocking curved jaws or teeth.
60.22	625.8.086	GRADER** ग्रेडर	A machine, either self-propelled or towed, having a blade within the wheelbase. (*See Drag, 60.13*)
60.23		GRITTER बजरी मोटर	A mechanical device for scattering uniformly a thin covering of grit, sand or shingle on the surface of a road.
60.24	625.8.085	HAND RAMMER दुरमुट, धम्मस	A heavy wooden or metal block attached to a handle which is raised vertically by hand and allowed to fall for the purpose of compacting loose material or for bedding paving material.

* The jaws or teeth are designed to dig into the material when the bucket is being lowered and to close so as to retain the material while bucket is being raised.

** It is used for shaping a subgrade, certain types of roads or for spreading loose materials.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.25		HEATER (Boiler) तापक	A tank or container equipped with means for heating tar or bitumen.
60.26		INDENTING ROLLER INDENT ROLLER दांतदार रोलर	A light roller with rolls having projecting teeth for impressing a pattern on a road surface.
60.27		JOINTING TOOL ARRISING TOOL गोल गुरमाला	A special float shapped for rounding the arrises of freshly placed concrete and road slabs.
60.28		JUMBO जम्बो	A movable stage carrying a number of rock drills, for use in tunnelling.
60.29		JUMPER झम्पक, झम्बल	A heavy bar, chisel or drill worked either by hand or by means of a hammer, for drilling rock preparatory to blasting.
60.30		MECHANICAL MIXER मशीनी मिश्रक	A power-driven machine, usually portable, consisting of suitable mechanism for the purpose of mixing materials such as concrete, asphalt, tarmacadam, etc.
60.31	625.8.085	MECHANICAL RAMMER मशीनी दुरमुठया, धम्मस	A power-driven machine in which a weight is lifted and allowed to fall upon the material to be compacted or bedded.
60.32		PAN MIXER कढाह मिश्रक	A mixing machine having a shallow open-topped drum or pan rotating about a vertical axis, and a paddle, whereby the contents of the drum are mixed.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.33		PICK OR PICK-AXE गैंती	A double-headed curved tool, attached to a long handle, having both ends pointed or one pointed and one chisel shaped.
60.34	625.8.086	PLANER* मशीनी रन्दा	A machine fitted with cutters and used for removing irregularities from black-top surfaces.
60.35		PNEUMATIC-TYRED** ROLLER वायवी-टायर रोलर	A roller having two axles on each of which are mounted a number of pneumatic-tyred wheels.
60.36		POWER SHOVEL† मशीनी बेलचा	A type of excavator operated by power and used principally against a bank or face of material.
60.37		PUG MILL मिट्टी मिश्रक	A machine for grinding and mixing wet materials, such as clay, mortar etc.
60.38		RAKE पंजा	A long handled tool with long projecting teeth used for handling loose materials.
60.39		ROAD HEATER (Road Burner) सड़क तापक	A machine for heating a road surface by causing flames or hot air to play upon it.

* The process is usually preceded by softening the surface.

** It is towed by a tractor and is usually capable of having its weight increased by the addition of ballast.

† The digging bucket is attached to a rigid arm and is capable of being forced upwards through the earth and away from the machine.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.40	625.8.084	ROAD ROLLER सड़क रोलर सड़क कूटने का इंजन	A towed or power-driven machine having smooth rigid rolls for rolling and compacting road material. The approximate weight of the roller is usually stated.
60.41		ROOTER RIPPER उन्मूलित्र	A machine mounted on wheels, capable of being towed by a tractor, and having one or more tines which are drawn through the ground for the purpose of loosening it and for pulling up roots.
60.42	625.8.5	SCARIFIER उत्पाटक	An independent machine or attached apparatus used for scoring and loosening the surface of a road to a uniform designated depth.
60.43	625.8.086	SCOOP स्कूप	A machine consisting essentially of a bucket or shallow container with a cutting edge, designed to excavate, load and transport over relatively short distances, and dump the material so collected.
60.44	625.8.086	SCRAPER खुरचनी-मशीन	A machine mounted on wheels consisting essentially of a large scoop, with a cutting edge, designed to excavate, load and transport over relatively short distances and dump the material so collected.
60.45		SCREED चपती	A strip (one of a pair) usually of wood or metal used as a guide for striking off or finishing a surface to a required form.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.46	625.8.084	SHEEPS FOOT ROLLER दुरमुठ रोलर	A roller, usually towed, having a single axle on which is mounted a cylinder or cylinders studded with projecting feet.
60.47		SMOOTHING IRON इस्तिरी	An iron tool used, when heated, for smoothing the surfaces and sealing the joints in asphalt.
60.48		SPRAYER फुहारा	An equipment for distributing fluid materials as a film, either by gravity or pressure over a road surface.
60.49		SPREADER बिछाई मशीन, विस्तरण मशीन	A machine mounted on wheels for distributing, while in transit, loose material over a road.
60.50		SPREADING BOX बिछाई बकस	A machine or appliance which receives road material and spreads it in an even but uncompacted layer.
60.51		TAMPER थापी	A wooden or metal template beam or frame, manually or mechanically operated used for shaping and consolidating surfaces.
60.52		TANDEM ROLLER टैन्डम रोलर	A road roller having two or more rolls of approximately the same width set one behind the other so that they operate in succession on the same track. Unless otherwise stated, it is implied that the machine has two rolls.
60.53		TEMPLATE फ़रमा	A full-sized mould, pattern or frame shaped to serve as a guide in forming or testing contour or shape.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.54		THREE-WHEEL ROLLER त्रिचक्र रोलर, तिपहिया रोलर	A road roller with one broad roll on the front axle operating on the middle of its track, and two narrower rolls on the rear axle operating on the sides of its track.
60.55		TIPPING LORRY उलटाऊ ठेला	A vehicle fitted with a body which is capable of being raised at one end and/or sideways in order that the contents may be discharged.
60.56		TIPPING WAGON उलटाऊ डिब्बा	A truck running on rails and fitted with a body which is pivoted in order that the contents may be discharged.
60.57		TRACTOR ट्रैक्टर	A self-propelled machine carried either on crawler tracks or on wheels, intended primarily to exert a powerful tractive force for towing other machines but often capable of serving as a mount for other equipmen (e. g. bulldozer, winch etc.), the combination forming a self-contained unit.
60.58		TREEDOZER* STUMPER वृक्ष उन्मूलित्र	A tractor on the front of which is mounted a blade specially designed for felling trees and uprooting stumps.
60.59		TREMIE कीप, ट्रैमी	A cylindrical tube, funnel shaped at the top, used for depositing concrete in water.

* The word "Treedozer" is also used for the equipment which, when mounted on a tractor constitutes a complete machine of the type stated above.

Definition No.	U. D. C. No.	TERM	DEFINITION
60.60		TRENCH DIGGER खाई खनित्र	A self-propelled power operated machine for digging trenches.
60.61		VIBRATING ROLLER कम्पन रोलर	A roller, either power-driven or towed in which the roll is subjected to mechanically applied vibrations.
60.62		VIBRATOR कम्पी	A machine which compacts a layer of freshly mixed concrete by vibrations.
60.63		WEIGH-BATCHER स्वमापी तोलवर्गक	A batching plant in which quantities of different materials are measured by weight.

SECTION 7—TRAFFIC.

खंड—7 यातायात

SUB-SECTION 7.1 GENERAL TERMS

उपखंड—71 साधारण शब्दावली

Definition No.	U. D. C. No.	TERM	DEFINITION
71.01		ACCELERATION LANE त्वरण गली	An additional traffic lane to enable a slow moving vehicle entering a major traffic artery to increase its speed to the rate at which it is convenient or safe to merge with the through traffic.
71.02		BOLLARD बोलार्ड, रक्षा स्तम्भ	A substantial post to define the position of a refuge and to prevent vehicles overrunning it.
71.03		BRAKE* EFFICIENCY ब्रेक क्षमता	The ratio of the effective braking force to the mass of the vehicle expressed as a percentage.
71.04		BRAKING DISTANCE ब्रेक दूरी	The distance traversed by a vehicle between the point at which brakes are applied and the point at which the vehicle comes to rest.
71.05		BRAKE REACTION TIME ब्रेक प्रतिक्रिया काल	The time lag or the brief interval between the perception of danger and the effective application of brakes.
71.06		CAPACITY वहन सामर्थ्य	The maximum number of vehicles that can pass a given point on a lane or a carriageway during one hour under the prevailing roadway and traffic conditions, without unreasonable delay or restriction to the driver's freedom to manoeuvre.

* A 100 percent efficiency would give a deceleration rate of 32.2 ft. per sec. per sec.

Definition No.	U. D. C. No.	TERM	DEFINITION
71.07		CHANNELIZING ISLAND विनयन द्वीप	An island that canalises traffic at a grade intersection into definite paths of travel to ensure safe and orderly movement.
71.08		CONTROLLED ACCESS नियंत्रित पहुँच	An approach from a highway to abutting property, the siting of which is subject to certain restrictions.
71.09		CONVOY सार्थ	Vehicles in motion that maintain a predetermined order and spacing in a group.
71.10		DECELERATION LANE मन्दन गली	An additional traffic lane to enable a vehicle to slow down, after it has left the stream of fast moving traffic, to a speed which is safe for any subsequent manoeuvre.
71.11		DENSITY (TRAFFIC) घनता (यातायात)	The number of vehicles, persons or animals passing per unit length of the carriageway at a specified time.
71.12		DESIGN SPEED आकल्पित चाल	The maximum safe speed assumed for the design and correlation of the physical features of a highway that influences the operation of vehicles.
71.13		DIRECTIONAL ISLAND विनयन द्वीप	Same as Channelising Island, 71.07.
71.14		DIVERGING विगमन	The dividing of a single stream of traffic into separate streams.
71.15		DIVIDED HIGHWAY विभाजित मुख्य मार्ग	A road on which traffic in one direction of travel is separated from that in the opposite direction by a median strip.

Definition No.	U. D. C. No.	TERM	DEFINITION
71.16		GYRATORY TRAFFIC चक्रगति यातायात, चक्रगति ट्रैफ़िक	Vehicular traffic circulating in one direction round a central island or islands, as in a traffic rotary.
71.17		HEADWAY (यानों की) दूरी, (यानों का) अन्तर	The distance from the front of a vehicle to the front of the one ahead in the same traffic lane.
71.18		HIGHWAY GRADE SEPARATION मार्गतल विभाजन	An intersection layout which permits crossing manoeuvres at different levels.
71.19		LAG DISTANCE विलम्ब दूरी, विलम्बान्तर	The distance covered by a vehicle moving at uniform speed during perception and brake reaction time.
71.20		MERGING विलयन	The converging of separate streams of traffic into a single stream.
71.21		ONE-WAY TRAFFIC एक दिशा यातायात	Traffic which is compelled by regulation to flow in one direction only.
71.22		PEAK TRAFFIC अधिकतम यातायात	Maximum flow of traffic at a place for a specified period of time.
71.23		PEDESTRIAN CROSSING (पैदल) पारपथ	A transverse strip of carriageway intended for pedestrians crossing the road.
71.24		PEDESTRIAN ISLAND पैदल द्वीप	A raised safety zone (*See 71.29.*)

Definition No.	U. D. C. No.	TERM	DEFINITION
71.25		PERCEPTION TIME बोधकाल	The time taken by the driver of a vehicle in motion to comprehend a danger before trying to take avoiding action.
71.26		REFUGE* आश्रय	An area near a junction set apart for the exclusive use of pedestrians crossing the carriageway.
71.27		RELATIVE SPEED सापेक्ष चाल	The rate of convergence of two vehicles as they approach a point of potential collision.
71.28		ROTARY INTERSECTION वर्तुल बहुल, चक्कर चौराहा	A road junction laid out for movement of traffic in one direction round a central island.
71.29		SAFETY ZONE आश्रय	Same as Refuge, 71.26.
71.30		SHUTTLE TRAFFIC शटिल ट्रैफ़िक, तसरी यातायात	Traffic constrained to flow first in one direction and then in the other.
71.31		SIGHT DISTANCE दृष्टि दूरी	The distance along the road surface at which a driver has visibility of an object, stationary or moving, at a specified height above a carriageway.
71.32		SKIDDING DISTANCE रपटन दूरी, फिसलन दूरी	The distance required to bring a vehicle to rest with all wheels locked under specified conditions.

* Usually it is protected, or is so marked or indicated by adequate signs as to be clearly visible at all times.

Definition No.	U. D. C. No.	TERM	DEFINITION
71.33		SINGLE-LINE TRAFFIC पांक्तिक यातायात, पांक्तिक ट्रैफ़िक	Traffic constrained to movement in a single direction in a traffic lane.
71.34		STOPPING DISTANCE रुकने की दूरी	The distance travelled by a vehicle from the time a danger is comprehended by the driver, to the actual stop i.e. the distance travelled during perception time and the brake-reaction time plus the braking distance.
71.35		TRACKING लीक चाल, लीक पड़ना	(a) The act of driving vehicles one behind another in approximately the same track. (b) Longitudinal depressions or markings on a road surface caused by the passage of vehicles following approximately the same path.
71.36		TRAFFIC यातायात, ट्रैफ़िक	Vehicles, persons, or animals travelling on a highway, considered collectively.
71.37		TRAFFIC CIRCLE यातायात वृत्त, ट्रैफ़िक चक्र	A central island at a junction, having a circular or an oval shape.
71.38		TRAFFIC CONCENTRATION (यातायात) घनता	Same as Density, 71.11.
71.39		TRAFFIC CUT ट्रैफ़िक की काट, यातायात की काट	The inter-section of two streams of traffic when circumstances preclude weaving.

Definition No.	U. D. C. No.	TERM	DEFINITION
71.40		TRAFFIC LANE यातायात गली	A unit width of carriageway which will safely accommodate a single line of vehicular traffic. Usually the width varies from 10 ft to 12 ft
71.41		VOLUME (TRAFFIC) परिमाण (यातायात)	The number of vehicles, persons, or animals passing a given point on a road during a specified period of time.
71.42		WEAVING वयन, बुनाई	The crossing of streams of traffic moving in the same general direction accomplished by merging and diverging.
71.43		WEAVING AREA वयन क्षेत्र, बुनाई क्षेत्र	The area of a carriageway in which weaving occurs.
71.44		WEAVING DISTANCE वयन दूरी, बुनाई की दूरी	The length of a carriageway, between adjacent radial routes at a rotary intersection, in which weaving occurs.
71.45		WEAVING LENGTH वयन दूरी, बुनाई की दूरी	Same as Weaving Distance, 71.44.
71.46		WEAVING SPACE वयन क्षेत्र, बुनाई क्षेत्र	Same as Weaving Area, 71.43.

खंड—7 यातायात

SUB-SECTION 72 SIGNS AND DIRECTIONS

उप खंड —7.2 संकेत और निर्देश

Definition No.	U. D. C. No.	TERM	DEFINITION
72.01		ADVANCE SIGN पूर्व संकेत	A sign that gives prior direction, warning, or guidance to traffic.
72.02		CARRIAGEWAY MARKING यानपथ चिन्ह	Marking by means of studs, white lines, etc. on the surface of a carriageway for the control, warning, guidance, or information of traffic.
72.03		CAUTIONARY SIGN चेतावनी संकेत	A sign indicating to traffic, usually by means of appropriate symbols, of their approach to a place where caution is required.
72.04		DIRECTION SIGN दिशा संकेत	A sign indicating the direction to a particular locality.
72.05		INFORMATIVE SIGN सूचना संकेत	A sign, other than that of prohibitory, mandatory, or warning significance, for the guidance of traffic.
72.06		LANE LINE गली रेखा	A marked longitudinal line, other than a centre line, separating two traffic lanes.
72.07		MANDATORY SIGN आदेश संकेत	A sign indicating to traffic an obligation to comply with a statutory regulation.
72.08		NAME-BOARD नाम-पट	A plate or panel giving the name of a road, bridge, river, town, or village, etc.
72.09		PROHIBITORY SIGN प्रतिषेध संकेत, मनाही संकेत	A sign indicating to traffic that the use of a highway by a specified class of traffic is forbidden or restricted.

Definition No.	U. D. C. No.	TERM	DEFINITION
72.10		ROAD SIGN ट्रैफ़िक संकेत, यातायात संकेत	A device mounted on a fixed or portable support to give, in the form of an inscription and/or symbol, warning, direction, or guidance to traffic.
72.11		ROUTE MARKER राह चिन्ह	A sign indicating, by means of a number, a device, or a colour, the course of a particular route.
72.12		TRAFFIC* SIGNAL यातायात सिगनल, ट्रैफ़िक सिगनल	A device for the control, warning or guidance of traffic.
72.13		TRAFFIC SIGN ट्रैफ़िक संकेत	Same as Road Sign, 72.10.
72.14		WARNING SIGN चेतावनी संकेत	Same as Cautionary Sign, 72.03.

* It may be operated manually, electrically, or mechanically.

खंड—8 विविध

Definition No.	U. D. C. No.	TERM	DEFINITION
80.01		BLEEDING (डांबर का) रिसना	The exudation, as a viscous liquid, of the free binder from a black-top surface.
80.02		BRAKING-FORCE CO-EFFICIENT* ब्रेक बल गुणांक, रोध बल गुणांक	A coefficient used as a measure of the resistance of a wheel to forward sliding on the road, and to the condition where brakes are applied to a wheel having forward motion only.
80.03		BULLING वर्धन	The enlargement of the bottom of a drilled or jumped hole by joining a small charge of explosive.
80.04		CORRUGATION लहर, नाली	Approximately regular and wave like deformations on a road, transverse to its centre line.
80.05		CRAZING (दरार की) जाली पड़ना	The cracking of a surface into small irregularly shaped contiguous areas.
80.06		DRILLING आबेधन, सूराख करना	The process of boring a hole in a material with a tool revolved by a suitable mechanism.
80.07		FAT SURFACE मोटी तह	A smooth patch on a black-top surface due to the excess of binder.
80.08		FUSE पलीता	Combustible material in the form of a cord or a flexible tube for igniting blasting charges.

* It is expressed as the ratio of the horizontal force in the plane of the wheel to the load on the wheel.

Definition No.	U. D. C. No.	TERM	DEFINITION
80.09		HAIR CRACK बाल, महीन दरार	An irregular, fine and shallow crevice or fissure on the surface of a material, like concrete, indicating that the material has fractured.
80.10		JUMPING झंपन	The process of sinking a hole in the ground by means of a long steel rod worked up and drawn by hand (as distinct from drilling).
80.11		OVER BURDEN अधिभार	(a) The soil or the superficial material overlying deposits of rock, sand, or gravel. (b) The material above a specified level in the ground.
80.12		RAVELLING (Fretting) उधड़ना	Disintegration of a road surface due to loss of bond between aggregate particles.
80.13		SIDEWAY-FORCE CO-EFFICIENT * पक्ष-बल गुणांक	A coefficient used as a measure of the resistance of a wheel to skidding on the road, and applied to the case where the wheel is free to rotate but has sideways as well as forward motion.
80.14		SKID-BRAKE PAN ब्रेक, टेडकी	An iron shoe or a wooden block or other device to enable animal-drawn carts to travel on steep gradients without the risk of sliding back or forward.

* It is expressed as the ratio of the force at right angles to the plane of the wheel to the load on the wheel.

Definition No.	U. D. C. No.	TERM	DEFINITION
80.15		SKIDDING* फिसलना	The motion of a vehicle with its wheels locked on a road surface.
80.16		SPIT छेव	The depth of earth pierced by the full length of a spade blade.
80.17		SPITTING सुलगना	The ignition of a safety fuse which is accompanied by a slight puff of smoke and sparks.
80.18		SWEATING पसीजना	Appearance of moisture on a surface like concrete, stone, etc.
80.19		WEAR घिसाई	Deterioration in, or diminution in the thickness of, a road surfacing by use.
80.20		WEATHERED अपक्षीण, छीजा हुआ	Partly decomposed or otherwise effected by exposure to weather or other natural causes.
80.21		WEATHERING अपक्षय, छीजन	Partial decomposition and/or change in colour at the surface of a natural or artificial material due to natural causes.

* It may be either longitudinal in the direction of motion of the vehicle or transverse, and is brought about by the application of a braking force on the wheels greater than the product of the mass of the vehicle multiplied by the coefficient of friction between the tyres and the road surface.

Definition No.	U. D. C. No.	TERM	DEFINITION
80.22		WHEEL-RUT पहिये की लीक	A longitudinal depression or groove on a road surface caused by the passage of vehicles following approximately the same path. [Same as Tracking, 71.35 (b).]

HIGHWAY ENGINEERING TERMS

मार्ग-इंजीनियरींग शब्दावली

SECTION 1

खण्ड 1

HIGHWAYS GENERAL, CLASSIFICATION

मार्ग-सामान्य वर्गीकरण

Definition No. *	Terms	Hindi Equivalents
11.01	BLIND ALLEY	बन्द गली
11.02	BRIDLE PATH	अश्व पथ
11.03	BY-PASS ROAD	बाहरी सड़क
11.04	CARRIAGEWAY	यान मार्ग
11.05	CART TRACK	गाड़ी का रास्ता, छकड़ा रास्ता
	†CIRCUMFERENTIAL HIGHWAY	परिधि मुख्य मार्ग
	CIRCUMFERENTIAL ROAD	परिधि सड़क
11.06	CYCLE TRACK	साइकिल रास्ता
11.07	DISTRICT ROAD, MAJOR	ज़िले की मुख्य सड़क
11.08	DISTRICT ROAD, OTHER	ज़िले की अन्य सड़क
11.09	DRIVEWAY	सवारी मार्ग
11.10	FIELD-PATH	पगडण्डी, खेतों की लीक
11.11	FOOT-PATH	पैदल पथ
11.12	FORMATION WIDTH	तैयार चौड़ाई
11.13	HIGHWAY	मुख्य मार्ग
11.14	INTERSECTION	चौराहा
11.15	INTERSECTION, FLARED	चौड़ा चौराहा
11.16	LANE	गली
11.17	LIMITED ACCESS HIGHWAY	सीमित अभिगमन मुख्य मार्ग
11.18	LOOP ROAD	चाप सड़क

* As given in Paper No. 146 and 170.

† Terms without definition numbers have not been defined in Paper No. 146 and 170.

11.19	MOTORWAY	मोटर मार्ग
11.20	NATIONAL HIGHWAY	राष्ट्रीय मुख्य मार्ग
11.21	PARKING PLACE	गाड़ी स्थान
	RADIAL HIGHWAY RADIAL ROAD	त्रिज्या मुख्य मार्ग त्रिज्या सड़क
11.23	RING ROAD	वलय सड़क
11.24	RIGHT-OF-WAY	मार्गाधिकार
11.25	ROAD	सड़क
11.26	ROAD LAND (Right-of-way)*	सड़कभूमि (मार्गाधिकार)*
11.27	ROAD MARGIN ROAD SIDE†	सड़क की पटरी या किनारा सड़क की पटरी या किनारा
11.28	ROADWAY	रोडवे, सड़क पथ
11.29	SERVICE ROAD	पिछला मार्ग, पिछवाड़े की सड़क
11.22	STATE HIGHWAY	राज्य मुख्य मार्ग
11.30	STREET TRACE	बाज़ार-सड़क, लीक
11.31	TRAFFIC LANE	यातायात गली
11.32	TOW PATH	गुन पथ,
11.33	VILLAGE ROAD	(गांव का) गलियारा

* Use of this term as synonymous with road land is deprecated.

† Synonymous with road margin.

SECTION 2

खण्ड 2

PRELIMINARY OPERATIONS

प्रारम्भिक क्रियाएँ

SUB-SECTION 2.1 LOCATION

उपखण्ड 2.1 स्थान निर्धारण

21.01	ALIGNMENT	रेखन, रेखांकन
21.02	ALIGNMENT POSTS, PEGS AND STONES	मार्ग रेखन खम्भे, खूँटे और पत्थर
21.03	CENTRE LINE	मध्य रेखा
21.04	DETOUR	चक्कर का मार्ग
21.05	DEVIATION	अदल बदल
21.06	DIVERSION	परिवर्त्तन, फेर-बदल
21.07	LOCATION	स्थान निर्धारण, निर्धारित स्थान
21.08	RECONNAISSANCE	देखभाल, पर्यवेक्षण
21.09	REFERENCE MARK	अभ्युद्देश चिन्ह
21.10	TURNING POINT	मोड़ बिन्दु

SUB-SECTION 2.2 SURVEYING

उपखण्ड 2.2 सर्वेक्षण

22.01	BASE LINE	आधार रेखा
22.02	BEARING	दिशा कोण, धारक, बेयरिंग
22.03	BENCH MARK	तल चिन्ह
	BUILDING LINE	तामीर सीमा
	BOUNDARY STONE	सीमा पत्थर
22.04	CHANGE POINT	परिवर्तन-विन्दु
22.05	CHECK LEVELS	पड़ताली तल
22.06	CONTOUR LINE	समोच्च रेखा
	CONTROL LINE	नियंत्रण सीमा
22.07	CROSS SECTION	आड़ी काट
22.08	DATUM	माप तल
22.09	FORMATION LEVEL	तैयार तल
	FURLONG STONE	फ़र्लांग पत्थर
22.10	G.T.S. BENCH MARK	महत्तम त्रिकोणमितीय सर्वेक्षण तलचिन्ह, म.त्र.स. तलचिन्ह
22.11	GROUND LEVEL	भूमि तल
22.12	LEVELLING	तल माप
22.13	LONGITUDINAL SECTION	अनुलम्ब काट
22.14	MAGNETIC BEARING	चुम्बक ध्रुव कोण
22.15	MEAN SEA LEVEL	औसत समुद्र तल
22.16	REDUCED LEVEL	निर्धारित तल
22.17	ROAD SURFACE LEVEL	मार्ग धरातल
22.18	SPOT LEVEL	स्थान तल
22.19	TEMPORARY BENCH MARK	अस्थायीतल चिन्ह
22.20	TRAVERSE	माला रेख
22.21	TYPICAL CROSS SECTION	नमूने की आड़ी काट, सामन्य आड़ी काट

SUB-SECTION 2.3 SETTING OUT

उपखण्ड 2.3 निशान लगाना

	ANGLE OF CURVATURE	वक्रता कोण
23.01	APEX OF A CURVE (Vertex)*	वक्र का शिरोविन्दु, वक्र की नोक
23.02	APEX DISTANCE OF A CURVE	वक्र शिरोविन्दु या नोक की दूरी
	BANKING	उठान, सलामी
23.03	BATTER	सलामी
23.04	BONING	सीध बाँधना
23.05	BONING RODS	सीध बाँधने के डण्डे
23.06	CAMBER	उभार, उत्तलता
	CANT	उठान, सलामी
23.07	CENTRE PEGS	बीच के खूंटे (खुँटियाँ)
	CENTRE OF CURVATURE	वक्रता केन्द्र
23.08	CROSSFALL	आड़ी सलामी, आड़ा ढाल
23.09	CROWN	शिखर
23.10	CURVE, DEGREE OF	वक्रांश
23.11	CURVE, HORIZONTAL	पड़ा मोड़, क्षैतिज वक्र
23.12	CURVE, TRANSITIONAL OR EASEMENT	अन्तर्वर्ती वक्र, अन्तर्वर्ती मोड़
23.13	CURVE, COMPOUND	यौगिक वक्र
23.14	CURVE, REVERSE	उत्क्रम वक्र, लहरिएदार मोड़
23.15	CURVE, VERTICAL	खड़ी गोलाई, उर्ध्व वक्र
23.16	CURVE, SUMMIT	उत्तल गोलाई
23.17	CURVE, VALLEY (Curve Sag)	अवतल गोलाई
23.18	DAGBEL	दाग़बेल
23.19	DEVIATION ANGLE, TOTAL	विचलन कोण, पूर्ण
	GRADE	ढाल
23.20	GRADIENT	ढाल
23.21	GRADIENT, AVERAGE	औसत ढाल
23.22	GRADIENT, LIMITING	अधिकतम ढाल
	GRADIENT, MAXIMUM	अधिकतम ढाल

* The use of terms given within brackets is deprecated.

23.23	GRADIENT, RULING	ढाल की इष्ट सीमा
23.24	INTERSECTION ANGLE	कटान कोण, प्रतिच्छेद कोण
	HAIR PIN BEND	कैंची मोड़
	INCLINE	ढाल, झुकाव
23.25	LOCKSPIT	दागबेल
23.26	OFFSET	खसका, अन्तर्लम्ब
23.27	OSCULATING CIRCLE	समत्रिज्या वृत्त
	OFFSET PEGS	अन्तर्लम्ब के खूँटे
23.28	PROFILE	रूप रेखा
23.29	RADIUS OF A CURVE	वक्र की त्रिज्या
23.30	RADIUS OF A CURVE, ABSOLUTE MINIMUM	वक्र की त्रिज्या, न्यूनतम
23.31	RADIUS,RULING	इष्ट अधिकतम त्रिज्या
23.32	RAMP	रपटा
23.33	REFERENCE OBJECTS, REFERENCE PEGS	इष्ट अभ्युद्देश के खूँटे
		इष्ट अभ्युद्देश के खूँटे
23.34	SHIFT	हटाव, शिफ़्ट
23.35	SIGHT DISTANCE	दृष्टि दूरी
23.36	SIGHT RAIL	दृष्टि पट्टी
23.37	SLOPE	ढलान
23.38	SUPERELEVATION	उठान, सलामी
23.39	TANGENT DISTANCE	स्पर्शरेखा की लम्बाई
23.40	TANGENT POINT	स्पर्श बिन्दु
23.41	TRANSITION LENGTH	अन्तर्वर्ती वक्र की लम्बाई
	TRUING	सीधा करना
23.42	TURNING RADIUS, MINIMUM	आवर्त की न्यूनतम त्रिज्या

SECTION 3.

खण्ड 3

PREPARATORY WORKS

तैयारी का काम

SUB-SECTION 3.1 EARTHWORKS

उपखण्ड 3.1 मिट्टी का काम

31.01	BACK-FILLING	पीछे की भरत
31.02	BALANCED EARTH-WORKS	सन्तुलित मिट्टी का काम, बराबर कटाई और भराई
31.03	BANK	बंद
	BANKFILL	भराव
31.04	BENCH	कगर बनाना
31.05	BENCHING	कगर
31.06	BORROWPIT	खतान, गड्ढा, नयांजलि,
31.07	CLAY	चिकनी मिट्टी
31.08	CLEARING	सफ़ाई
31.09	CONSOLIDATION	कुटाई
31.10	CUT	खुदाई
31.11	CUT AND FILL	खुदाई और भराई
31.12	CUTTING	कटान, कटाई
31.13	DRAGGING	पटेला फेरना
31.14	EARTH WORK	मिट्टी का काम, कटाई और भराई
31.15	EMBANKMENT	भराव
31.16	FILL	भरना, भराई करना, भराई
31.17	FILLING	भरन, भराई
31.18	GRADING	काँट-झाट
31.19	GRUBBING	जड़ें खोदना
31.20	LAND-SLIDE	पहाड़ गिरना
31.21	LEDGE	शिला-फलक
31.22	LOAM	दोमट
31.23	MARL	मार्ल

31.24	PEAT	पीट
31.25	QUICKSAND	चलती बालू, बहती बालू
31.26	RUNNING SAND	चलती बालू, बहती बालू
31.27	SAND	बालू, रेत
31.28	SETTLEMENT	बैठना
31.29	SHALE	शेल
31.30	SIDE CUT	पार्श्व कटान
31.31	SILT	कीचड़, गाद
31.32	SLIP	सर्पण, खिसकना
31.33	SOIL	मिट्टी
31.34	SPOIL	फ़ालतू मिट्टी
31.35	SPOIL BANK	फ़ालतू मिट्टी का ढेर
31.36	STEPPING	कगर
31.37	SUBSIDENCE	धँसना
31.38	SUB-SOIL	नीचे की मिट्टी, अधोमृद
31.39	SURCHARGE	अधिभार
31.40	TRIMMING	काँट-छाँट

SUB-SECTION 3.2 SOILS

उपखण्ड 3.2 मिट्टी

32.01	ABSORPTION	अवशोषण
32.02	ADSORPTION	संश्लेषण
32.03	BASE EXCHANGE	आयन विनिमय
32.04	BINDER	बन्धक
32.05	BLACK COTTON SOIL	काली मिट्टी
32.06	BROWNIAN MOVEMENT	ब्राउनीय गति
32.07	CALIFORNIA BEARING RATIO	कैलिफ़ोर्निया धारणभार-अनुपात
32.08	CAPILLARITY	केशिकत्व
32.09	CENTRIFUGE MOISTURE EQUIVALENT	केन्द्रप्रसारित्र नमीतुल्यांक
32.10	CLAY	चिकनी मिट्टी
32.11	COHESION	संसक्ति
32.12	COHESIVE WATER	संसक्तिशील पानी
32.13	COLLOIDS	कलिल
32.14	COMPACTION	कुटाई, संघट्टन
32.15	COMPACTION, DEGREE OF	कुटाई की मात्रा, संघट्टन की मात्रा
32.16	CONSISTENCY INDEX	संघनता अनुपात
32.17	CONSOLIDATION	कुटाई
32.18	DENSITY, DEGREE OF	घनत्व की मात्रा
32.19	DUST	धूल
32.20	DUST RATIO	धूल अनुपात
	EARTH PRESSURE, PASSIVE, TOTAL	मिट्टी का कुल निष्क्रिय दबाव
32.21	EFFECTIVE SIZE	सार्थक नाप
32.22	EXPANSION LIMIT, LINEAL	एकायामी विस्तार की सीमा
32.23	EXPANSION, LINEAL	एकायामी विस्तारया
32.24	FIELD MOISTURE EQUIVALENT	क्षेत्र नमी तुल्यांक

32.25	FLOCCULATION	संकणन
32.26	FLOCCULATION RATIO	संकणन सीमा
32.27	FLOCCULATION LIMIT	संकणन अनुपात
32.28	FLOW CURVE	प्रवाह वक्र
32.29	FLOW INDEX	प्रवाह सूचक
32.30	FREE WATER	उन्मुक्त जल
32.31	FRICTION, ANGLE OF	घर्षण कोण
32.32	GRAIN DIAMETER	कण व्यास
32.33	GRAIN SIZE	कण परिमाण
32.34	HUMUS	ह्यूमस
32.35	HYDROSTATIC PRESSURE RATIO	स्थिर द्रवीय दबाव अनुपात
32.36	LEACHING	संप्रक्षालन
32.37	LIQUID LIMIT	सरल सीमा
32.38	LOAM	दोमट
32.39	MARL	मार्ल
32.40	MODULUS OF ELASTICITY	लचक गुणांक
32.41	MODULUS OF INCOMPRESSIBILITY	असम्पीड्यता का गुणांक
32.42	MODULUS OF SUBGRADE REACTION	निम्नतल प्रतिक्रिया का गुणांक
32.43	MODULUS OF SUBGRADE REACTION DYNAMIC	निम्नतल प्रतिक्रिया का चल गुणांक
32.44	MOISTURE CONTENT	नमी मात्रा
32.45	OPTIMUM MOISTURE CONTENT	अनुकूलतम नमी अनुपात
32.46	MOISTURE INDEX	नमी सूचक
32.47	OVERBURDEN	अधिस्तर
32.48	PEAT	पीट
32.49	PERCENT FINER	सूक्ष्मतर प्रतिशत
32.50	PERMEABILITY	पारगम्यता
32.51	PERMEABILITY COEFFICIENT	पारगम्यता गुणांक
32.52	pH VALUE	पी० एच० मूल्य
32.53	PLASTICITY INDEX	लोच सूचक

32.54	PLASTIC LIMIT	लोच सीमा
32.55	POROSITY	छिद्रिलता, झरझरापन
32.56	REMOULDING INDEX	पुनर्घटन सूचक
32.57	REPOSE, ANGLE OF	विश्राम कोण
32.58	SAFE BEARING CAPACITY	निःसंकट (सकुशल) धारण क्षमता
32.59	SAND	बालू, रेत
32.60	SAND, COARSE	मोटी रेत
32.61	SAND, FINE	महीन रेत
32.62	SATURATED SOIL	संतृप्त मिट्टी
32.63	SATURATION, DEGREE OF	संतृप्ति की मात्रा
32.64	SHALE	शेल
32.65	SHRINKAGE LIMIT	संकुचन सीमा
32.66	SHRINKAGE LIMIT, LINEAL	संकुचन सीमा, एकायामी
32.67	SHRINKAGE, LINEAL	संकुचन, एकायामी
32.68	SHRINKAGE LIMIT, VOLUMETRIC	संकुचन सीमा, आयतनीय
32.69	SHRINKAGE RATIO	संकुचन अनुपात
32.70	SHRINKAGE VOLUMETRIC	संकुचन, आयतनीय
32.71	SILT	गाद
32.72	SOIL	मिट्टी
32.73	SOIL MORTAR	गम्बर की मिट्टी
	SOIL MOISTURE, CONTENT	मिट्टी में नमी की मात्रा
32.74	SOIL STABILISATION	मिट्टी का स्थिरीकरण
32.75	SOIL WATER, ADSORBED	संश्लेषित भू-जल
32.76	SOIL WATER, CAPILLARY	केशिक भू-जल
32.77	SOIL WATER, GRAVITATIONAL	उन्मुक्त भू-जल
32.78	SOIL WATER, HYGROSCOPIC	वायुसंश्लेषित भू-जल
32.79	SUB-SOIL	अधोमृद, नीचे की मिट्टी
32.80	SURFACE TENSION	सतही तनाव

32.81	SURCHARGE	अधिभार
32.82	SURCHARGE, ANGLE OF	अधिभार कोण
32.83	TOP SOIL	ऊपरी मिट्टी
32.84	TOTAL ACTIVE EARTH PRESSURE	मिट्टी का कुल सक्रिय दबाव
32.85	TOTAL PASSIVE EARTH PRESSURE	मिट्टी का कुल निष्क्रिय दबाव
32.86	TOUGHNESS INDEX	पुष्टता सूचक
32.87	UNIFORMITY COEFFICIENT	समानता गुणांक
32.88	VOID RATIO	रिक्तता अनुपात
32.89	VOID RATIO CRITICAL	रिक्तता अनुपात, सीमान्तिक (क्रान्तिक)
	UNDISTURBED SAMPLE	बिन छेड़ा नमूना
32.90	VOLUMETRIC CHANGE	आयतनीय संकुचन
32.91	WATER CONTENT	नमी की मात्रा
32.92	WATER GRADIENT	जल स्तर
32.93	WATER TABLE	जल स्तर

SUB-SECTION 33 DRAINAGE

उपखण्ड 33 जलनिकास

33.01	AFFLUX	चढ़ाव (पानी का)
33.02	AQUEDUCT	जलसेतु
33.03	BACKWATER	चढ़ा हुआ पानी
33.04	BACKWATER CURVE	चढ़े हुए पानी का वक्र
33.05	BACKWATER LEVEL	चढ़े हुए पानी की सतह
	BORE HOLE	बरमा छेद
33.06	BOX CULVERT	चौकोर पुलिया
33.07	BOX-DRAIN	चौकोर मोरी
33.08	BOX-GUTTER	चौकोर नाली
33.09	BREACHING SECTION	नितल-खण्ड
33.10	BRIDGE	सेतु या पुल
33.11	BUOYANCY	उत्प्लावकता, तरण शीलता
33.12	CATCHWATER DRAIN	जल रोक नाली
33.13	CATCHMENT AREA	स्रवण क्षेत्र
33.14	CATCHMENT BASIN	स्रवण क्षेत्र
33.15	CATCH-PIT	कैच पिट
33.16	CATCH-DRAIN	जलरोक नाली
33.17	CAUSEWAY (Irish Bridge)	कौज़वे, रपटा
33.18	CAUSEWAY, RAISED	उठा रपटा
33.19	COEFFICIENT OF CONTRACTION	आकुंचन गुणांक
33.20	COEFFICIENT OF DISCHARGE	निकास गुणांक
33.21	COEFFICIENT OF ROUGHNESS OR RUGOSITY	खुरदुरेपन का गुणांक
33.22	CRITICAL VELOCITY	सीमान्तिक (क्रान्तिक) वेग
33.23	CULVERT	पुलिया
33.24	CURTAIN WALL	रक्षक दीवार या भीत
33.25	CUT-OFF WALL	रिसन-रोक दीवार
33.26	DITCH	खाई

33.27	DRAIN	नाला या नाली, मोरी
33.28	DRAINAGE	जल निकास
33.29	DRAINAGE BASIN	स्रवण क्षेत्र
33.30	EROSION	काट, अपरदन
33.31	FLOOD ESCAPE	बाढ़ जल निकास, बाढ़ मार्ग
33.32	FLOOD GATE	बाढ़ द्वार
33.33	FLOOD WAY	बाढ़ मार्ग
33.34	FLUSH CAUSEWAY	तल मार्ग
33.35	FORD	घाट
33.36	GRATING	जाली
33.37	GROYNE	परिवाल, ठोकर
33.38	GUIDE BANK	नियामक बाँध
33.39	GULLEY	घट्टा, चौबच्चा
33.40	GUTTER	नाली
33.41	HERRING-BONE DRAIN	आड़ी मोरी
33.42	HIGH LEVEL CAUSEWAY	ऊँचा रपटा
33.43	HYDRAULIC GRADIENT	द्रवीय ढलान
33.44	HYDRAULIC GRADIENT LINE	द्रवीय ढलान रेखा
33.45	HYDRAULIC MEAN DEPTH	औसत द्रवीय गहराई
33.46	HYDRAULIC MEAN RADIUS	औसत द्रवीय गहराई
33.47	INFILTRATION	अन्तर्क्षरन
33.48	INTENSITY OF RAINFALL	वर्षा परिमाण
33.49	INTERCEPTING DRAIN	जलरोक नाली
33.50	INVERT	पेंदा
33.51	INVERTED SIPHON (Siphon Culvert)	उल्टा साइफ़न
33.52	KERB INLET	कर्ब की मोरी
33.53	LEADER DRAIN	बड़ी नाली
33.54	LEADING DRAIN	बड़ी नाली
33.55	LEAD-OFF DRAIN	निकास नाली
33.56	MAN-HOLE	नर-गम
33.57	PERCOLATION	टपकना
33.58	PIPE DRAIN	नल मोरी

33.59	PIPING	नीर क्रिया
33.60	PUDDLE	लोंदा
33.61	PUG	गारा भरना
33.62	RAINWATER	वर्षा जल
33.63	RAISED CAUSEWAY	उठा कौज़वे, उठा रपटा
33.64	RATE OF RUN-OFF	अपवाह की दर
33.65	RUBBLE DRAIN	रोड़ों की नाली
33.66	RUN-OFF	अपवाह
33.67	SCOUR	तल रदन
33.68	SEEPAGE	रिसना
33.69	SEWER	निचली नाली
33.70	SIDE DRAIN	किनारे की नाली
33.71	SOAKING PIT	सोख-गड्ढा
33.72	SOAKAWAY	सोख-गड्ढा
33.73	SPILLWAY	पक्की ढाल
33.74	SPUR	परिवाल, ठोकर
33.75	STORM-WATER	बरसाती पानी
33.76	STORM-WATER DRAIN	बरसाती नाली
33.77	STONE DRAIN	रोड़ों की नाली
33.78	SUBGRADE DRAIN	अधस्तर नाली
33.79	SUBMERSIBLE BRIDGE	निमज्जक पुल
33.80	SUBSOIL DRAIN	अधोमृद नाली
33.81	SUMP (Sump Well)	चौबच्चा
33.82	UPLIFT	उत्क्षेप
33.83	VIADUCT	उत्तार
33.84	WASTE WEIR	पक्की ढाल
33.85	WATER CUSHION	पन गद्दी, जल गद्दी
33.86	WATER SHED	पन धारा
33.87	WEEP HOLE	जल छिद्र
33.88	WETTED PERIMETER	भीगा पारमाप

SUB-SECTION 3.4 STRUCTURES

उपखण्ड 3.4 तामीर, संरचना

34.01	ABUTMENT	पील पाया, अन्त्याधार
	ABUTMENT, GRAVITY	भारस्थित अन्त्याधार
34.02	ABUTMENT PIER	आधार स्तम्भ
34.03	AFFLUX	चढ़ाव (पानी का)
	APRON	पल्ला
34.04	AQUEDUCT	जलसेतु
34.05	ARCH	मेहराब, डाट, चाप
34.06	ARCH BRIDGE OR CULVERT	डाटदार पुल या पुलिया
	ARCH RING	डाट छल्ला
34.07	ARCH STONE	डाट का पत्थर
	BALANCED CANTILEVER BRIDGE	संतुलित टोडा पुल
34.08	BARRIER	रोक, नाकाबन्दी
	BASCULE BRIDGE	उत्तोलन पुल
34.09	BEAM	शहतीर, कड़ी
34.10	BEARING	दिशा कोण, धारुक, बेयरिंग
	BEARING PRESSURE	धारण दबाव
	BEARING LOAD	धारण भार
	BOAT BRIDGE	नौकापुल
34.11	BOW STRING GIRDER	प्रत्यंचाया चिल्ला गर्डर
	BOWSTRING GIRDER BRIDGE	प्रत्यंचा पुल
34.12	BOX CULVERT	चौकोर पुलिया
	BRACED FRAME	कैंचीदार चौखटं, द्वार मुख
34.13	BRACING	सहारा, सहार
34.14	BRIDGE	सेतु, पुल
	BRIDGE LOADINGS, CLASS A. B.	पुल, भार (A, B श्रेणी)
	BRIDGE, TRUSS	कैंचीदार पुल

34.15	BUTTRESS	पुश्ता
34.16	CABLE FENCE	तार की बाड़
34.17	CAISSON	केसून
34.18	CANTILEVER	टोडा, प्रबाहु
34.19	CAUSEWAY (Irish Bridge)	पुलिया, कौज़वे
34.20	CAUSEWAY RAISED	ऊँचा कौज़वे
	CELLULAR ABUTMENT	कोशमय अन्त्याधार
34.21	CENTRING, FALSE WORK	ढूला
	CHORDS (OF BRIDGE)	उपा, जीवा (पुल की)
	CLEAR SPAN	खुलापाट
34.22	CLEARANCE	अन्तर
34.23	COFFER DAM	कौफ़र डैम
34.24	COLUMN	खम्भा, थंभ
34.25	CONTINUOUS GIRDER OR BEAM	अनेकाधार गर्डर या शहतीर या कड़ी
34.26	CORNICE	कंगनी, कार्निस
	COUNTERFORT ABUTMENT	पुश्तेदार अन्त्याधार
34.27	CROSS-GIRDER	आड़ी गर्डर
	CROWN	शिखर
34.28	CULVERT	पुलिया
34.29	CURTAIN WALL	परदा दीवार
	CUSHION, OVER ARCH	गद्दी (डाट के ऊपर)
34.30	CUT WATER	पनकट, नाक
34.31	DECK BRIDGE	पाटन पुल
34.32	DECK LEVEL	पाटन तल
	DYKE	डाइक
34.33	EASE WATER	पनमेल
	EFFECTIVE SPAN	सार्थक पाट
	ELASTIC ARCH	इलास्टिक डाट
	ELLIPTICAL ARCH	अंडाकार डाट
34.34	EXTRADOS	बहिःस्तर

34.35	FENCE	बाड़, जंगला
	FERRY	घाट
	FERRY BOAT	नाव (घाट की), घटहा
	FIXED BEARING	अचल धारक
34.36	FLOATING BRIDGE	नाव पुल
	FLYING FERRY	रज्जु नाव
	FOOT BRIDGE	पैदल पुल
	FOOTINGS	खसका (नींव)
	FORMWORK	ढूला
34.37	FREE BOARD	उछोधर अन्तर
34.38	GIRDER	गर्डर
	GIRDER BRIDGE	गर्डर पुल
	GRADE LEVEL CROSSING	समतल पारक
34.39	GROYNE	परिवाल, ढोकर
34.40	GUARD RAIL	जंगला
	HANGERS, BRIDGE	आलम्ब (पुल)
34.41	HAUNCH	कूल्हा
34.42	HEAD-WALL	ऊपरी दीवार
	HINGES OF BRIDGE	पुल के कब्जे
	HINGED ABUMENT	कब्जेदार अन्त्याधार
	HINGED BEARING	कब्जेदार धारुक
34.43	IMPACT	व्याघात
34.44	INTRADOS	अन्तःस्तर
34.45	KEY STONE	चाबी पत्थर
34.46	LIVE FENCE	हरी बाड़
34.47	OVER BRIDGE	उपरगामी पुल
	PANEL	दिला
	PARABOLIC ARCH	परवलय डाट
34.48	PARAPET	मुंडेर
34.49	PEDESTRIAN GUARD RAIL	पैदल बचाव जंगला
34.50	PIER	स्तम्भ
34.51	PILE	लट्ठा, बल्ली, पाइल, स्थूण
34.52	PITCHING	पत्थर लगाना
34.53	PLATE GIRDER	प्लेट गर्डर

34.54	PONTOON BRIDGE	पीपों का पुल
	PORTAL FRAME	कैंचीदार चौखटा, द्वार मुख
	POWER FERRY	मोटर नाव
	PRE-STRESSED CONCRETE	पूर्व प्रतिबलित (कंकरीट)
	PROTECTION WORK	रक्षा कार्य, बचाव कार्य
34.55	REINFORCEMENT	प्रबलन
34.56	RETAINING WALL	पुश्ता दीवार
34.57	RETURN WALL	समानान्तर दीवार
34.58	REVETMENT	ढलवां खड़ंजा
	RIGID-FRAME BRIDGE	अनम्य ढाँचे का पुल
	RISE, ARCH	ऊंचाई, उठान (डाट)
	RIVER CROSSING	घाट
34.59	ROAD-RAIL BRIDGE	सड़क-रेल पुल
	ROAD RAIL LEVEL CROSSING	सड़क-रेल समतल पारक
34.60	ROCKER BEARING	रौकर बेयरिंग, झूलता धारुक
34.61	ROLLER BEARING	बेलन धारुक
	SAFE BEARING LOAD	निःसंकट (सकुशल) धारुक
34.62	SAFETY FENCE	बचाव जंगला, सुरक्षा जंगला
	SEGMENTAL ARCH	बादामी डाट
	SEMI CIRCULAR ARCH	गोल डाट
34.63	SHEET PILES	चादरी खूंट, पट्ट स्थूण
	SHORING	सहारा देना
34.64	SHUTTERING	तख्ता बन्दी
	SKEW ARCH	तिरछी डाट, कमान टेक, चाप आधार
34.65	SKEW-BACK	तिरछा पुलया या तिरछी पुलिया
34.66	SKEW-BRIDGE OR CULVERT	शिला पुल या पुलिया
34.67	SLAB BRIDGE OR CULVERT	चल पट्ट धारुक
34.68	SLIDING BEARING	अन्तःस्तर तल
34.69	SOFFIT LEVEL	पाट, विस्तार, दर
	SPAN	खुला पाट
	SPAN, CLEAR	सार्थक पाट
	SPAN, EFFECTIVE	

34.70	SPANDREL	चाप स्कन्ध
34.71	SPANDREL WALL	स्कन्ध दीवार
34.72	SPRINGING LINE	उठान रेखा
34.73	STOCK SUBWAY (Cattle Creep)	पशु गलियारा
34.74	STRIKING	ढूला उतारना
34.75	STRIPPING	तख्तावन्दी निकालना, डामर या कोलतार छूटना या उतरना
34.76	SUBMERSIBLE BRIDGE	निमज्जक पुल
34.77	SUBSTRUCTURE	निचली संरचना, निचली तामीर
34.78	SUBWAY	तल-मार्ग, तल-राह
34.79	SUPERSTRUCTURE	ऊपर की संरचना, ऊपरी तामीर
34.80	SUSPENSION BRIDGE	झूला पुल
	T-BEAM BRIDGE	टी-बीम पुल
	THREE PIN ARCH	तीन कब्ज़ी डाट
34.81	THROUGH BRIDGE	अन्तर्गामी पुल
34.82	TOE WALL	रोक दीवार
34.83	TRESTLE BRIDGE	घोड़ी पुल
34.84	TRUSS	कैंची
	TRUSS OF BRIDGE	पुल की कैंची
	TWO PIN ARCH	दो कब्ज़ी डाट
	'U' ABUTMENT	नालरूप अन्त्याधार
34.85	UNDER BRIDGE	अधोगामी पुल
34.86	VIADUCT	उत्तार
34.87	VOUSSOIR	डाट का पत्थर
	WEB OF A GIRDER	पेटा (गर्डर का)
34.88	WING WALL	दीवार-बाज़ू (पुल या पुलिया की)

SECTION 4

खण्ड 4

SURFACE CONSTRUCTION

सतह निर्माण

SUB-SECTION 4.1 SURFACING TYPES

उपखण्ड 4.1 सतह के प्रकार

41.01	BITUMEN CONCRETE SURFACING	बिटुमन मिली रोड़ी की बिछाई
41.02	BITUMEN OR TAR MACADAM	बिटुमन या तारकोली मकैडम
41.03	BLACK-TOP SURFACE	काली सतह
	BREAK OF JOINT	जोड़ भंग
41.04	BRICK PAVING	ईंटों का फ़र्श
	BRICK ROAD	ईंटों की सड़क
41.05	CARPET	फ़र्श
41.06	CEMENT BOUND MACADAM	सीमेण्टबद्ध मकैडम
41.07	CEMENT CONCRETE SURFACING	सीमेंट कंकरीट की बिछाई
	CONCRETE ROAD	कंकरीट की सड़क
41.08	EARTH ROAD	कच्ची सड़क
	FASCINE	गट्ठा
41.09	GRAVEL ROAD	बजरी की सड़क
	GROUT	पतला मसाला, ग्राउट
41.10	GROUTED MACADAM	पतली भराई का मकैडम, ग्राउट मकैडम
	GROUTED SURFACE	पतले मसाले से बनी सतह, ग्राउट की सतह
	GROUTING	पतले मसाले की भराई, ग्राउट भरन
41.11	KANKAR ROAD	ककंर की सड़क
41.12	LATERITE ROAD	जामुनी पत्थर की सड़क

41.13	LIME STONE ROAD	चूना पत्थर की सड़क
	METAL	रोड़ी
41.14	MOORUM ROAD	मूरम की सड़क
41.15	PAVEMENT	उपस्तरण, फ़र्श
41.16	PAVING	खड़ंजा
	ROAD BED	मार्ग तल
	SOLING	आधार, सोलिंग
41.17	STONE-SETT PAVING	पत्थर के चौके का खड़ंजा
41.18	STONE-BLOCK PAVING	पत्थर का खड़ंजा
41.19	SURFACING	ऊपर की सतह
41.20	SURFACE DRESSING OR PAINTING	डामर बिछाई
41.21	TAR CONCRETE SURFACING	तारकोली कंकरीट की बिछाई
41.22	TOP COAT	ऊपर की सतह
41.23	WATER-BOUND MACADAM	पानी मिला मैकेडम
41.24	WEARING COAT (Wearing Course)	ऊपरी स्तर
41.25	WEARING SURFACE	उपस्तरण, फ़र्श
41.26	WOOD BLOCK PAVING	लकड़ी का खड़ंजा

SUB-SECTION 4.2 CONSTRUCTION DETAILS

उपखण्ड 4.2 निर्माण विवरण

42.01	BASE COAT	निचली तह
42.02	BASE COURSE	आधार की तह
42.03	BERM	पटरी
42.04	BLINDING	महीन भरती, छाना देना
42.05	BLOTTER	सोखन, चूषक
42.06	BOTTOM COAT	निचली तह
42.07	CENTRAL RESERVE	मध्यारक्ष
42.08	CONSOLIDATION	कुटाई
42.09	COURSE	रद्दा
42.10	CRETEWAYS	क्रीटमार्ग
42.11	CUSHION (SUB-CRUST)	गद्दा
42.12	DIVIDING STRIP	विभाजिका
42.13	EDGING	किनारा बन्दी
42.14	EXPANSION JOINT	फैलाव जोड़, विस्तार सन्धि
42.15	FENDER	छाज
42.16	FLUSHING	धुलाना
42.17	FOOT PAVEMENT	पटरी
42.18	FORMATION	तैयारी, तैयार स्तर
42.19	FOUNDATION	नींव
42.20	GRITTING	बजरी बिछाना
42.21	IMPROVEMENT	सुधार
42.22	INTERMEDIATE COURSE	बीच की तह
42.23	JOINT	सन्धि, जोड़
42.24	JOINT, CONTRACTION	संकुचन जोड़
42.25	KERB	कर्ब, किनारा
42.26	MAINTENANCE	देखभाल
42.27	MARGIN	पट्टी
42.28	MEDIAN STRIP	बिचली पट्टी
42.29	PATCHING	टांका लगाना, कारी लगाना
42.30	PICKING	उखाड़ना

42.31	POT HOLES	गड्ढा
42.32	PRE-COATING	पूर्व लेपन
42.33	PRE-MIXING	पूर्व मिश्रण
42.34	PRIME COAT	पहला लेप
42.35	RAMMING	कुटाई
42.36	RECONDITIONING	दुरुस्ती, सुधार
42.37	RENEWAL	नवीकरण
42.38	REPAIRING	मरम्मत
42.39	REPAVING	खड़ंजा बदलना
42.40	RESURFACING	फ़र्श बदलना
42.41	SAND PAPER SURFACE	खुरदरा फ़र्श
42.42	SCARIFYING	मशीन से उखाड़ना
42.43	SEALING COAT	जल-सह लेप
42.44	SHAPING	आकार देना
42.45	SHOULDER (Haunch)	पटरी
42.46	SLEDGING	तुड़ाई
42.47	SPRAY	फुहार देना, फुहारना
42.48	STAGGERED JOINT	विषम जोड़
42.49	SUB-BASE	बिचली तह, उपाधार
42.50	SUB GRADE (Road Bed)	निचली सतह
42.51	SURFACE	सतह
42.52	SURFACE TREATMENT	सतह का सुधार
42.53	TACK COAT	चिपकाऊ लेप
42.54	TEMPORARY DIVERSION	सामयिक मार्ग,अस्थायी विक्षेप
42.55	TRACKWAYS	लीक, पटरी
42.56	TRIMMING	काट-छाँट
42.57	VERGE	विभाजिका
42.58	WHEEL GUARD	मुँडेर रक्षक

SECTION 5—MATERIALS

खण्ड 5–सामग्री

SUB-SECTION 5.1—CLASSES

उपखण्ड 5.1 प्रकार

51.01	AGGREGATE	मिलावा
51.02	ASPHALT	डामर, असफ़ाल्ट
51.03	ASPHALTITE	अस्फ़ाल्टाइट
51.04	ASPHALTIC CEMENT	अस्फ़ाल्टी सीमेण्ट
	ASPHALTIC CONCRETE	अस्फ़ाल्टी कंकरीट
51.05	BALLAST	रोड़ी
51.06	BASALT	बसाल्ट
51.07	BINDER	बन्धक
51.08	BITUMEN	बिटूमैन
51.09	BITUMEN EMULSION	बिटूमैन तरल
51.10	BITUMINOUS MATERIAL	बिटूमैन सामग्री (पदार्थ)
51.11	BLINDAGE	छाना
51.12	BLOWN BITUMEN	फूँका बिटूमैन
51.13	BOULDER	गोल पत्थर, बोल्डर
	BRICK	ईंट
51.14	CEMENT	सीमेण्ट
51.15	CHIPPING	ज़ीरा
51.16	COAL TAR PITCH	कोलतार की तलछट
51.17	COARSE AGGREGATE	मोटा मिलावा
51.18	CONCRETE	कंकरीट
51.19	CONGLOMERATE	कौंग्लोमैरेट, पिंडशिला
51.20	CREOSOTE	क्रिओसोट
51.21	CRUDE TAR	सखरा (बेनिखरा) कोलतार
51.22	CRUSHER RUN STONE	मशीन के टूटे पत्थर
51.23	CURING (RAPID, MEDIUM OR SLOW)	जमने वाला बिटूमैन (शीघ्र, मध्यम, मन्द)
51.24	CUT-BACK BITUMEN	हल्का (कटबैक) बिटूमैन
	DEHYDRATED TAR	निर्जलित तारकोल

SUB-SECTION 5.2 PROPERTIES AND TEST

उपखण्ड 5.2 धर्म और परीक्षण

52.01	ABRASION	घिसन, रगड़, अपघर्षण
52.02	ABSOLUTE VOLUME	निरपेक्ष आयतन
52.03	ABSOLUTE WEIGHT	निरपेक्ष तौल
52.04	ABSORPTION	अवशोषण
52.05	ACTUAL VOLUME	वास्तविक आयतन, असल आयतन
52.06	ACTUAL WEIGHT	वास्तविक तौल, असल तौल
52.07	ADHESION	चिपकन, चिपकाऊपन
52.08	ANGLE OF REPOSE	विश्राम कोण
52.09	ATTRITION	रगड़, संघर्षण
52.10	BOND	बन्ध
52.11	BULKING	फूलना
52.12	BULK DENSITY	स्थूल घनत्व
52.13	CEMENTING VALUE, OF AN AGGREGATE	बन्धनगुणांक
52.14	COHESION	संसक्ति
52.15	CONSISTENCY	संघनता
52.16	CREEP	सरक, सर्पण
52.17	CRUSHING VALUE, OF AGGREGATES	अपघर्षण गुणांक (मिलावे का)
52.18	CURING	जमना, पकना
52.19	CURING PERIOD	पकाई काल, पकाई अवधि
52.20	DENSITY	घनत्व
52.21	DUCTILITY	तन्यता
52.22	ELASTICITY	प्रत्यास्थता, लचक
52.23	EQUIVISCOUS TEMPERATURE OF TAR	तुल्य श्यानताप (कोलतार का)
52.24	FINAL SETTING TIME OF CEMENT	पूरा जमने की अवधि, पूर्ण संदृढन काल
52.25	FINENESS	बारीकी, सूक्ष्मता
52.26	FINENESS MODULUS	बारीकी या सूक्ष्मता गुणांक

52.27	FINENESS TEST	बारीकी की जाँच, सूक्ष्मता परीक्षण
52.28	FLASH POINT	दमकाँक
52.29	FLOW-TABLE TEST	प्रसारपरीक्षण
52.30	FRENCH CO-EFFICIENT OF WEAR	फ्राँसीसी घर्षण गुणांक
52.31	HARDENING PERIOD OF CEMENT MORTAR OR CEMENT	बल ग्रहण काल (सीमेण्ट के मसाले या सीमेण्ट का)
52.32	HYDROMETER	द्रवमापी
52.33	IGNITION POINT	ज्वलनांक
52.34	INITIAL SET	संदृढन आरम्भ, जमने का आरम्भ
52.35	INITIAL SETTING TIME OF PORTLAND CEMENT	संदृढन आरम्भ काल, जमना आरम्भ होने की अवधि
52.36	MECHANICAL ANALYSIS	यांत्रिक विश्लेषण
52.37	MELTING POINT	गलनांक
52.38	MESH	छेद (जाली के)
52.39	ORGANIC IMPURITY	कार्बनिक अपद्रव्य
52.40	PENETRATION, MEASUREMENT OF	वेधन (का माप)
52.41	PERMEABILITY	पारगम्यता
52.42	PLASTICITY	लचक, प्रत्यास्थता
52.43	POROSITY	सुषिरत्व, सरन्ध्रता
52.44	PROPORTIONING	समानुपातन
52.45	QUARTERING	चतुर्थांशीकरण, चौथाईकरण
52.46	RESILIENCE	प्रतिस्कन्दन
52.47	SAMPLING	नमूना निकालना
52.48	SEDIMENTATION TEST	कल्कन परीक्षण
52.49	SIEVE ANALYSIS	चलनी विश्लेषण
52.50	SLUMP	अवपात
52.51	SLUMP TEST	अवपात परीक्षण
52.52	SOFTENING POINT	मृदुकरणांक
52.53	SOUNDNESS	समांगता

51.25	DIORITE	डायोराइट
51.26	DOLOMITE	डोलोमाइट
51.27	FILLER	पूरक
51.28	FINE AGGREGATE	महीन मिलावा, ज़ोरा
51.29	FIXED CARBON	कारबन की गाद
51.30	FLINT	फ़िलिण्ट, चकमक पत्थर
51.31	FLUXING AGENT	द्रावक द्रव्य (सामग्री)
51.32	FREE CARBON	अविलेय कार्बन
51.33	GNEISS	नीस
51.34	GRADING	अनुपातन
51.35	GRADED MATERIAL	अनुपातित सामग्री
51.36	GRANITE	ग्रैनाइट
51.37	GRANULITE	ग्रैनुलाइट, कठिला
51.38	GRAVEL	बजरी
51.39	GRIT	कंकरी
51.40	HARD CORE	कड़ी तह
51.41	HIGH ALUMINA CEMENT	अधिक अल्युमिनी सीमेंट
51.42	HIGH EARLY-STRENGTH CEMENT	शीघ्र बलग्राही सीमेंट
51.43	HORN BLENDE	हौर्न ब्लैण्ड
51.44	HORN BLEND SCHIST	हौर्न ब्लैण्ड सिस्ट
51.45	HUMUS	ह्यूमस
51.46	HYDRAULIC CEMENT	जलपुष्ट सीमेण्ट
51.47	LAITANCE	लेटैंस (सीमेंट का दूध)
51.48	LAKE ASPHALT	झील का डामर, झील का एसफ़ाल्ट
51.49	LATERITE	लैटेराइट, जाम्भाश्म, जामुनी पत्थर
51.50	LIME STONE	चूने का पत्थर
51.51	MARBLE	संगमरमर
51.52	MASTIC ASPHALT	असफ़ाल्टी बजरी
51.53	MEDIUM CUT-BACK BITUMEN	मध्यम हल्का बिटूमैन
51.54	MOORUM	मूरम

51.55	MORTAR	मसाला
51.56	MUCK	कर्दम
51.57	NATURAL ASPHALT	प्राकृतिक डामर या असफ़ाल्ट
51.58	NORMAL-SETTING CEMENT	साधारण जमने वाला सीमेन्ट
51.59	PEGMATITE	पैगमैटाइट
51.60	PITCHING STONE	जुड़ाई का पत्थर
51.61	PIT-RUN GRAVEL	खान की बजरी
51.62	PORPHYRY	पौरफ़ाइरी
51.63	PORTLAND CEMENT	पोर्टलैंड सीमैण्ट
51.64	PRIMER	सोखनशील बन्धुक, प्राइमर
51.65	QUARTZ	क्वार्ट्ज़, स्फटिक
51.66	QUARTZITE	क्वार्ट्ज़ाइट
51.67	QUICK-SETTING CEMENT	शीघ्र जमने वाला सीमेण्ट
51.68	RAPID CURING CUT-BACK BITUMEN	शीघ्र जमने वाला हल्का बिटूमैन
51.69	RAPID-HARDENING PORTLAND CEMENT	शीघ्रबलग्राही सीमैण्ट
51.70	REFINED ASPHALT	निखरा हुआ डामर
51.71	REINFORCED CONCRETE	प्रबलित कंकरीट
51.72	ROAD METAL	सड़क की रोड़ी
51.73	ROAD STONE	सड़क की रोड़ी
51.74	ROAD TAR	सड़क का तारकोल
51.75	ROCK ASPHALT	खनिज असफ़ाल्ट
51.76	RUBBLE	रोड़े, अनगढ़े पत्थर
51.77	SAND STONE	बलुवा पत्थर, बालुका
51.78	SCHIST	सिस्ट
51.79	SCREENINGS	छान
51.80	SHALE	शेल
51.81	SHINGLE	जल बजरी
51.82	SLATE	स्लेट
51.83	SLOW CURING CUT-BACK BITUMEN	धीरे जमने वाला हल्का बिटूमैन
51.84	SYENITE	स्येनाइट

best service at a minimum cost. Efforts have been made to achieve this object on the lines of development in more advanced countries.

1.2. The Star & Grid Formula, evolved by the Nagpur conference of Chief Engineers[1] for calculating the lengths of roads necessary for an area, was accepted as the basis for fixing the targets of road milage. Having fixed the target of lengths required in an area, selection of roads for Phase I Programme in the State was influenced mainly by the demands of few persons and by suggestions put forward by Government departments based on consideration of their own needs.

1.3. On execution of this programme, it was realised that the programme was not always in accordance with the needs of the people. There were some cases where less important roads were constructed and the claims of really important ones were ignored.

1.4. So, realising the importance of a proper selection of the works, it was decided that Statewide surveys should be made to collect data for rational planning of highways.

1.5. A beginning was made in a small way some years ago when an economic survey of few western districts was taken up. Attention was mainly paid to marketing facilities and details regarding population and agricultural area of various villages were collected and areas contributing to the trade of various marketing centres were plotted on maps. These factors gave indication of flow of traffic and population served by a particular alignment[2].

In a Paper "Fundamentals of Highway Needs and Highway Planning"[3] it was suggested that factual studies covering economic, fiscal, traffic, and engineering aspects should be carried out for highway planning on scientific basis. Studies in respect of some of the suggestions contained in the Paper were undertaken in a few districts. It was felt that detailed investigations covering most of the items given in that Paper should be carried out. The formulation of the scheme of Fact Finding Survey described in this Paper is the result.

1.6. Highway development is a continuous process and as such the plan should take into account the needs of the future. Also, the schemes should be phased according to their necessity and importance over a period of years. Therefore, a Fact Finding Survey has been undertaken before the end of the first Five-Year Plan period. So far the survey has been carried out

in about 15 districts and the second Five-Year Plan has been evolved on the basis of the study.

1.7. The Fact Finding Survey, in brief, consists of collection of economic and other data and proposals for construction or improvement of roads from various authorities, compilation of the data, preparation of maps and evolving Master Plan.

2. ORGANIZATION FOR THE FACT FINDING SURVEY

2.1. The survey has been carried out considering a district as a unit. The ideal unit would have been a subdivision or a tehsil but that would have involved more expenditure and time, specially because Uttar Pradesh has as many as 51 districts. With a view to complete the survey as quickly as possible, the whole of the State has been divided into 17 groups consisting of three districts each and the work is being taken up in succession in these groups.

2.2. One overseer, assisted by one draftsman a tracer and an enumerator is in charge of a district and there are 3 such parties working. The work of these three overseers is supervised by one Assistant Engineer under the Planning Circle. The Planning Organization, with the Chief Engineer as the head, consists of the following:

1. Superintending Engineer (Planning)
2. Executive Engineer, Planning Division

Wholetime Staff

3.	Assistant Engineer, Planning	1
4.	Overseers	3
5.	Draftsmen	3
6.	Tracers	3
7.	Enumerators	4
8.	Typist	1
9.	Clerk	1

3. WORKING PROCEDURE

3.1. The party under the charge of an overseer visits the headquarter of a district and fixes its camp there. The draftsmen

and the tracer start making the maps, and the overseer along with the enumerator collects data and proposals and also fills in the questionnaire, Appendix 3, by local enquiries. The overseer also checks the tracings of the map. The information so collected is then plotted on maps. Then new highways are carefully planned and these proposals are scrutinised in head office. The roads so selected form part of the Master Plan, i.e. the ultimate pattern of highways required for the district.

4. COLLECTION OF DATA

4.1. To illustrate the details, Barabanki District has been selected as an example. This district lies to the east of Lucknow and Barabanki, the headquarters of the district, is about 18 miles from Lucknow.

4.2. The party headed by an overseer started work at Barabanki in the first week of May 1954. The overseer and the enumerator started collection of relevant data, details in Appendix 1, from various offices and other sources in the district. It includes information regarding important marketing centres, population, number of bullock carts, etc., in the various villages.

The draftsman prepared tracings of the district map to the scale of 1 in. to 4 miles. The information collected, was also plotted on the various maps as described in para 7.1. Simultaneously proposals for new roads from various administrative authorities, representatives of the people like the M.L.As., M.Ps., M.L.Cs., District Board, District Planning Officer, etc., were collected. A specimen of the information collected from District Planning Officer is given in Appendix 2.

The party visited a large number of important villages and filled in the questionnaire, Appendix 3, by making enquiries from local people regarding important features of the village, local requirements of roads and other proposals for further road programme. The existing roads were also inspected and their present condition and existing traffic were noted, Photos 1 and 2. The questionnaire being comprehensive, the information and details collected provide sufficient data for the preparation of the Master Plan.

This ' on the spot enquiry ' also enables the staff to verify the information collected from various sources and to get an idea of the traffic intensity on the roads.

Photo 1. **Present condition of a road in the district**

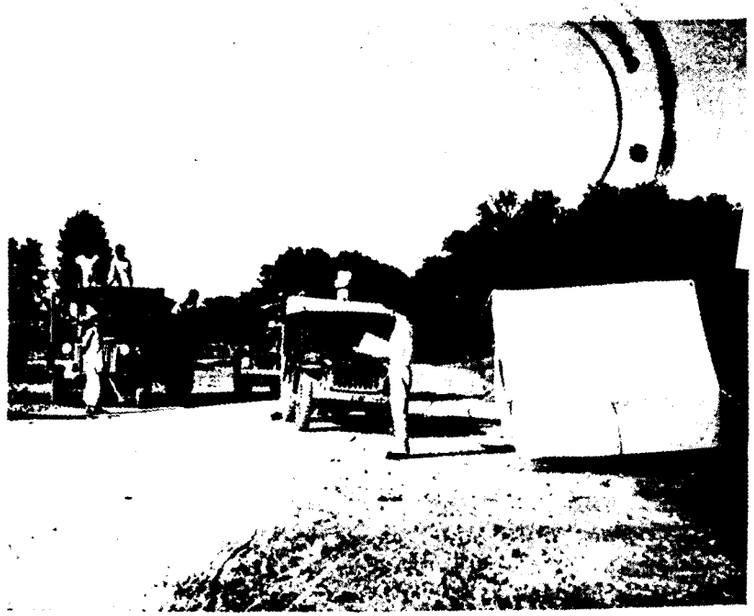


Photo 2. **Traffic census being carried out on a road**

5. ROAD MILAGE REQUIREMENT

5.1. The milages required for the various districts have been worked out according to the Star & Grid Formula[1], Appendix 4, and the deficiency or surplus found. This formula is based on two main considerations, namely, (i) the area should have metalled road grid so that no place is more than 5 miles of a metalled road, and (ii) if the railways serve the area well enough, roads are not required. But the existing system of roads and railways have not been planned on such considerations. Hence the milage of railway running parallel to the road should not be counted for subtraction in the formula. Similarly the roads which are surplus to the requirements worked out by the Grid & Star considerations should be excluded from the existing road milage.

5.2. In the district of Barabanki, for example, the metalled road milage according to Star & Grid Formula, works out to 249 miles. It will be seen from Plate I that about 63 miles of railway run parallel to the road. Besides, Barabanki-Zaidpur road lies within 3 miles of the two existing metalled roads. As such the calculated requirement should be increased by an amount equal to the sum of these two lengths.

6. SATURATION SYSTEM

6.1. Road milage can be further verified from Saturation System based on U. S. method of highway planning[4]. In order to obtain the milage in a district which can be added without any decrease in the utility per mile, the existing road system called System 'A' is compared with two other systems 'B' and 'C', comprising additional roads which have been selected on considerations of productivity and population only.

6.2. The three systems are as under, Plate I:

System 'A' — the existing system of roads — 341 miles

System 'B' — the existing system of roads plus 39½ miles — 380½ miles

System 'C' — system 'B' plus 36 miles of roads — 416½ miles

6.3. The productivity served directly per mile by the different systems and the number of villages served classified into 3 groups

having population of 1,000 to 2,000, 2,001 to 5,000 and above 5,000, are tabulated in Table 1.

TABLE 1

Utility by Population and Productivity

System	Number of villages served with Population of			Total of 1 of col. 2 + Col. 3 + 2 × Col. 4	Utility per mile population basis Col. 5 ÷ Col. 1	Total productivity served directly in lakhs of maunds	Utility per mile productivity basis Col. 7 ÷ Col. 1
	1,000 to 2,000	2,001 to 5,000	Above 5,000				
1	2	3	4	5	6	7	8
System A- 341 miles	140	44	6	126	0.369	283.20	0.830
System B- 380.5 miles	159	50	6	141.5	0.372	318.24	0.837
System C- 416.5 miles	174	51	6	150	0.362	343.95	0.825

6.4. A comparative study of columns 6 and 8 of Table 1 shows that the utility per mile on population and productivity basis increases up to a limit of additional 39.5 miles and beyond that it starts decreasing. Hence it is safe to assume that system 'B' obtained by adding 39.5 miles to the existing milage is saturated and is of greater benefit than the system 'C'. Therefore, milage up to the extent of 39.5 miles can be safely added to the existing system.

The optimum metalled milage for the district of Barabanki thus works out to 380. Having fixed the target milage for the district, new roads are selected to bring the length of roads to this figure.

7. SELECTION OF ROADS

7.1. All the information collected, as described in paras. 4.1 and 4.2, was plotted as far as possible in maps.

Map No. 1, Plate I, showing productivity in maunds per acre and the roads under the saturation system.

The places visited by the survey party are also indicated on this map.

Map No. 2, Plate II, showing the general details such as police stations, post offices, markets, etc. It also shows villages according to population in three categories—between 1,000 and 2,000, between 2,001 and 5,000 and above 5,000. The proposals received from various sources are also marked on this map.

Map No. 3, Plate III, showing villages grouped according to number of carts present in them. It also shows the existing traffic intensity in tons on different roads. This information helps in selection of roads for new construction, modernisation and reconstruction.

7.2. New Roads

The proposals received are filled in the proforma as shown in Appendix 5. Each proposal is then scrutinised and the abstract of roads recommended is prepared. Priority is fixed according to the utility of roads.

While planning, importance is given to gaps in the State highway system which, generally, are through roads running east-west or north-south. Even though these gaps are not important to the district yet first priority is given to them. Next in the order of priority are the inter-district links to open up the inter-district communications. Connections to tehsil headquarters and markets with the district headquarters and making farm to market roads for transport of the produce from agricultural areas come next.

7.3. Roads for Reconstruction and Modernisation

Apart from new roads, reconstruction and modernisation are also provided in the Master Plan according to the need of the traffic and present condition of the surface.

8. MASTER PLAN

8.1. The Master Plan, Plate IV, is then prepared after detailed study of all the maps and statements to meet the requirements of population, productivity, traffic and the other considerations. It will be seen that no village of about 5,000 population is beyond one mile of a metalled road and no village having a

population between 2,001 and 5,000 is beyond a distance of 3 miles from a road. It can also be said that no place in the district is beyond 5 miles of a metalled road. It is also claimed that practically no marketing centre, post office, police station, tehsil or pargana headquarter is beyond 2 miles of a road.

8.2. In the Master Plan are included all the roads executed in the Phase I and Five-Year Plan. The other roads have been divided into Phase II and Phase III schemes according to priority fixed on consideration of utility and importance.

8.3. In view of the limitations of funds for the second Five-Year Plan, the whole Phase II scheme cannot be taken up simultaneously and as such only a limited number of metalled roads having high priorities have been chosen for inclusion in second Five-Year Plan.

8.4. A statement showing the utility values of the existing system, Phase II scheme and the Master Plan of roads in Barabanki district in respect of population and productivity is given in Appendix 6. Appendix 7 gives the percentages of the number of villages, productivity, population and area served by the existing system, Phase II scheme and the Master Plan. This is shown diagrammatically in the Fig. in Appendix 7.

Comparison of the statements given in Appendices 6 and 7 for various districts will enable one to judge whether any particular district has got minimum requirements. Also, the requirements of roads for any chosen unit of productivity, population and area can be found out.

9. SECOND FIVE-YEAR PLAN

9.1. Phase II scheme for all the districts of the State was prepared with the idea that all works under this phase will be taken up immediately after completion of first Five-Year Plan. This could not be done as funds provided for the second Five Year were meagre.

9.2. Phase II scheme for the State roughly amounted to Rs 44 crores, whereas second Five-Year Plan is for about $\frac{1}{3}$rd of the amount. Hence a further selection of important projects out of the Phase II scheme of the districts had to be made for preparation of District second Five-Year Plans. Therefore, the construction of all new unmetalled roads have been omitted and those metalled roads which have been given top priority by the people as well as those roads which are required from planning considerations have been included in the second Five-Year Plan.

9.3. It is expected that 2,770 miles will be completed by the end of second Five-Year Plan. The milage of metalled roads in the State after the completion of first Five-Year Plan will be 11,430. Hence, although there will be 14,200 miles after the second Five-Year Plan yet the State will be short of 2,284 miles of metalled roads even according to the Star & Grid Formula.

9.4. The planning of highways on scientific basis is bound to bring satisfaction to the people as only those roads which serve the need of population best are provided in the Plan.

ACKNOWLEDGMENT

The data given in the Paper is compiled by the Fact Finding Survey Organization under the Planning Circle of Uttar Pradesh, P. W. D., and is published with the kind permission of the Chief Engineer, P. W. D.

REFERENCES

1. Proceedings of Chief Engineers' Conference on Post-War Road Development in India. Published by the Indian Roads Congress—3rd impression.

2. 'Basis of Road Planning' by Jagdish Bahadur, Indian Roads Congress Journal, Vol. XII-5, September 1948.

3. 'Fundamental of Highway Needs & Highway Planning' by D. G. Bhagat and Jagdish Bahadur, Indian Roads Congress Journal, Vol. XIII-3, January 1949.

4. Inter-regional Highways, U. S. Government. Printing Press, Washington.

Appendix 1

DETAILS OF DATA TO BE COLLECTED

S. No.	Item	Source of Receipt
1	List of hospital and dispensaries...	Civil surgeon's office.
2	,, post and telegraph offices	Post office.
3	,, police stations and out posts	S. P's Office.
4	,, railway stations ...	Station masters.
5	,, marketing and industrial centres	Tehsil records and District Board Offices.
6	,, fairs ...	do.
7	,, cane collecting centres ...	Compiled from questionnaire, Appendix 3.
8	,, towns and notified areas ...	District Board Offices.
9	,, inspection houses—D. B., P.W.D. and canals	Respective Offices.
10	,, alluvial villages ...	District Collectors' Office.
11	,, flooded areas ...	do.
12	,, existing roads under charge of P.W.D.	P.W.D.
13	,, do. ...	District Board Office.
14	,, ferries ...	do.
15	,, government buses ...	do.
16	,, export and import of goods at various stations	Station Masters.
17	,, traffic census ...	C.E. Office, and calculated from the questionnaire.
18	,, labour and material rates	P.W.D.
19	,, bullock carts census (village wise)	Tehsil.
20	,, population (village-wise) ...	—
21	,, pargana-wise population density	Calculated.
22	,, pargana-wise productivity	Calculated.

Appendix 2

PROPOSALS FOR ROADS AND BRIDGES IN BARABANKI DISTRICT—RECEIVED FROM PLANNING OFFICER, BARABANKI.

S. No.	Name of Proposal.	Reasons advanced by the Proposer.	Comments of A.E. (P)
1.	Reconstruction of Barabanki-Haider-garh road & a bridge over Gomati.	(1) It will connect Haidergarh Tehsil with the district headquarters. (2) It will also create a shortest route for Sultanpur & Raibareilly districts.	
2.	Metalling of 'kutcha' road from Mohmoodabad to Bilsar via Fatehpur, Ramnagar Badosarai, Kotwa, Tikaitnagar Sarai Barai.	(1) This road will provide the shortest route from Sitapur to Gonda & Faizabad. (2) It will also provide transport facilities between Sudhiamau and Badosarai within National Extension Service Block. (3) It will also connect tehsil Fatehpur with the important towns of Ramnagar & Ganeshpur. (4) It will also connect Fatehpur and Ramnagar town with Tikaitnagar & Daryabad towns and R. S. ghat tehsil. (5) Ramnagar and Tikaitnagar towns will be directly connected with Rudauli.	

Appendix 3

QUESTIONNAIRE FOR ORIGIN AND DESTINATION STUDY FOR FACT FINDING SURVEY

1. Name of person ... Shri Abdul Hai Saheb.
2. Present occupation ... Chairman, Town Area, Dewa.
3. Village ... Dewa.
4. Pargana ... Dewa.
5. Tehsil ... Nawabganj.
6. District ... Barabanki.
7. Important features of the village whether it is connected by unmetalled or metalled road, has got a railway station, police station/out post, or telgraph office, school, mandi, factory, is a cane collection centre, hospital etc.

   Cattle fair is held every October. In April, high officials come to visit and pay homage at Majar Haji Waris Ali Shah Saheb.

8. Nearest Milage of:
   (a) an unmetalled road — Zero.
   (b) metalled road — Zero.
   (c) railway station — 8 miles Barabanki & 10 miles Fatehpur.
9. (a) Population — 4,000
   (b) Main produce — Wheat, gram, sugar cane, tobacoo, potatoes mangoes, govas.

QUESTIONS

1. How many roads and carts tracks pass through your village?

   Name some important villages on each road.

   (1) Barabanki-Fatehpur, (2) Dewa (Chinhat-Lucknow) (3) Dewa-Kursi

   Important villages on these roads are shown in maps*.

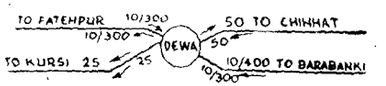
2. Which route is mostly used by the villagers; for what purpose and for going where?

   (1) Barabanki-Fatehpur Road: Business, court, tehsil and for going to Lucknow for business.

* Not included—[Ed].

(2) Dewa-Chinhat: For going to Lucknow to avoid octroi.

How many numbers of carts travel on each road every day? This should give number of carts going out and coming in the average by different roads separataly.



Is the approach to your village an all-weather road?

Yes.

If not, for how much period it remains out bf use?

Where do you generally go out for?

(a) Your household purchases: local.

(b) Selling your sugar cane: Barabanki.

(c) Selling your other products, as wheat etc., Local, Lucknow & Faizabad.

(d) Purchasing cattle: local.

(e) Purchasing manure: 200 maunds, local.

(f) Attending markets, fair etc.: local, Barabanki & Lucknow.

3. Where do you need a bridge (new or reconstructions): Nil.

4. What are your proposals for new roads or for improvement of existing roads and seasons for the same?

   (1) Improvement of Barabanki-Dewa-Fatehpur Road. The present surface cannot stand traffic.

   (2) Metalling of Dewa-Chinhat Road. This will provide a short-cut to Lucknow. Distance will be reduced from 26 to 20 miles.

   (3) Majar Haji Waris Ali Shah Saheb: Hundreds of people collect here twice a year. A cattle fair and an exhibition are held here for which nearly 2 lakhs of persons collect.

STAR & GRID FORMULA

Appendix 4

For metalled roads which are classified as National Highways, State Highways and Major District Roads, the required milages for an area is equal to:

$$A/5 + B/20 + N + 5T + D - R$$

where A: Agricultural Area of the region.

B: Non-agricultural area of the region.

N: Number of towns & villages having a population of 2001 to 5000

T: Number of towns and villages having a population over 5000

D: An allowance for agricultural and industrial development during next 20 years, which is at present assumed nil in this State, as against 15 per cent average proposed for all States in the Nagpur Plan.

R: Railway milage in the area under consideration.

For unmetalled roads which are classified as other district roads and village roads, the required milage is equal to:

$$V/5 + Q/2 + R + 2S + D$$

where V: Number of villages with population of 500 or less

Q: Number of villages with population of 501–1000.

R: Number of villages with population of 1001–2000.

S: Number of villages with population of 2001–5000.

D: An allowance for agricultural and industrial development during next 20 years, which at present is assumed nil per cent, for this State as in the case of metalled roads.

Appendix 5

PROPOSALS RECEIVED FROM VARIOUS SOURCES—FOR DISTRICT BARABANKI

Name of proposal	Milage	Recommended by	Does it form gap in State Highway route	Does it form inter-district link	Does it form link with existing metalled roads in same district	Names of towns & villages within ten miles of the roads				No. of villages of population 1000 to 2000 within 2 miles of the road	Number of villages within 2 miles of road having carts			Other important places served	Reasons advanced by the proposers	Reasons for justifying selection or rejection
						Population above 5000		Population between 2001-5000			Above 50	Between 50-25	Between 25-10			
						Name	Important features	Name	Important features							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fatehpur–Ramnagar—Badosarai—Tikaitnagar Road.	28-0	D.D.A. II Tehsildar D.P.O. M.L.A.	No.	No.	Yes.	1. Fatehpur	Town Area, P.S., P.O.H. Factory Market Cane Collecting Centre, Canal I.H. Tehsil	1. Ram Nagar 2. Kantri 3. Inchauli 4. Tikaitnagar	Town Area, P.S., P.O. Sugar Factory H. Market. ... ... S.P.O., Market Town Area	11	4	14	33	Kotwa Fair Place	(1) D.P.O. & M.L.A. It will provide transport facilities between Sudhiamau and Bado-Sarai between the National Extension Service block. (2) It will connect Fatehpur with the important towns Ramnagar, Ganeshpur and Tikaitnagar. (3) Kutwa J. Das is an important place from the religious point of view & melas are held on every pornamasi with two specially big melas held every year. By, constructing this road pucca Kutwa J. Das will be very well connected with the area of Fatehpur Tehsil. **Tehsildar:** There is no metalled road from H. Qrs. to this place. There is also police station at Ramnagar & the traffic is almost at a standstill during rains. This hinders administration and the public are inconvenienced.	This road is very important because (a) the portion from Ramnagar to Tikaitnagar is a State Highway gap. (b) It serves the area of the National Extension Service block at Sudhiamau and Badosarai. (c) The road connects a large number of important places like Fatehpur, Ramnagar, Kutwa, Ganeshpur, Badosarai and Tikaitnagar. (d) One Sugar mill at Burwal lies on this road. (e) It connects all these places to their respective Tehsil Headquarters as Fatehpur Ramanehighat. (f) Kutwa an important fair place is served by this road. (g) There are a number of markets, police stations, hospital, etc. on this road. (h) The area has not got any metalled road at present and requires one very badly. (i) The entire road is an existing O.D.R. of Phase I. (j) The traffic at present varies between 50 to 125 tons per day which will increase after metalling. (k) The area is in part very productive and highly populated. Hence the road is recommended for metalling in the Master Plan. The portion Ramnagar-Tikaitnagar is given first priority & Fatehpur-Ramnagar, 6th priority in metalled roads.

Appendix 6

UTILITY VALUE OF THE EXISTING SYSTEM, PHASE II PLAN AND MASTER PLAN ROADS IN RESPECT OF POPULATION AND PRODUCTIVITY

System	Number of villages served with population			Total productivity served in lakhs of maunds	Length of Road per lakh maunds of produce considering total produce of the district	Total population served	Length of road per thousand of population considering total population of the district	Length of road per sq. mile considering the total area in the district
	Above 5000	2001 to 5000	1001 to 2000					
Total for the District	6	60	231	466.07	—	12,64,120	—	1722 sq. miles
Existing Milage.								
Metalled Roads =215 miles	6	32	92	190.416	0.461	5,52,432	0.170	0.125
Unmetalled Roads =123½ miles	—	12	45	101.45	0.265	2,59,076	0.098	0.072
Total : =338½ miles	6	44	137	291.866	0.726	8,11,508	0.268	0.197
Phase II Plan Milage.								
Metalled Roads =275¼ miles	6	35	113	232.08	0.591	6,53,557	0.218	0.160
Unmetalled Roads =137¼ miles	—	14	48	107.938	0.295	2,81,405	0.109	0.080
Total : =412½ miles	6	49	161	340.018	0.886	9,34,962	0.327	0.240
Master Plan Milage.								
Metalled Roads =345¼ miles	6	41	143	277.908	0.747	7,95,504	0.273	0.200
Unmetalled Roads =137¼ miles	—	15	29	93.918	0.294	2,36,108	0.109	0.080
Total : =482½ miles	6	56	172	371.826	1.041	10,31,612	0.382	0.208

NOTE :—1. It is assumed that a road serves an area only within two miles of it on either side.

2. The milage of Phase II and Master Plan include the existing road milage also.

3. The unmetalled road milage includes only the new proposed unmetalled roads and the O.D.Rs. and V.Rs. of Phase I which have not been metalled.

4. The existing milage includes the roads provided in the Phase I and the First Five-Year Plan for the district in addition to those existing at the time of starting the Phase I.

Appendix 7

PERCENTAGE OF VILLAGES, PRODUCTIVITY, POPULATION AND AREA SERVED BY EXISTING SYSTEM, PHASE II PLAN AND MASTER PLAN.

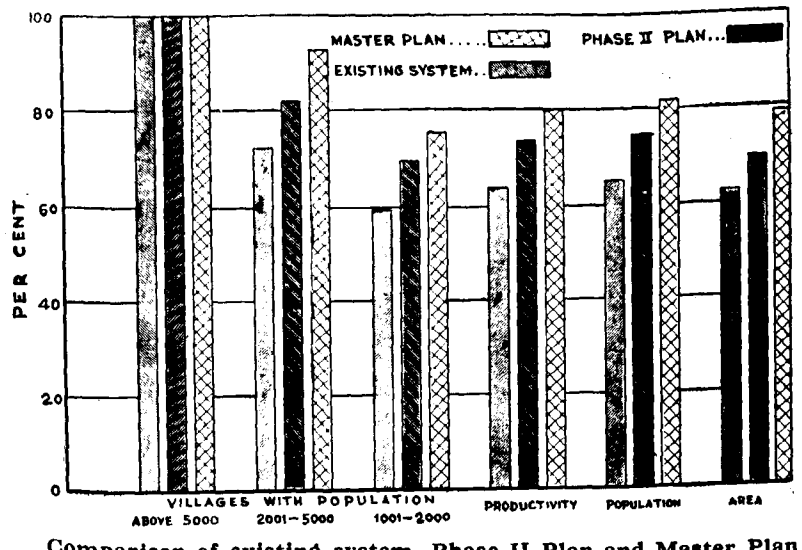
	Served by Existing System Percentage	Served by Phase II Plan Percentage	Served by Master Plan Percentage
Villages with Population			
Above 5000	100	100	100.00
Between 2001–5000	73.33	81.67	93.33
Between 1000–2000	59.31	69.69	74.45
Productivity	62.62	72.95	79.77
Population	64.19	73.96	81.61
Area	61.61	70.56	77.99

Note:

Existing System: Includes P.W.D. metalled roads, District Board metalled road and O.D.R's and V. R's at end of Phase I and the First Five-Year Plan.

Phase II Plan: Includes in addition to existing system the roads metalled and unmetalled provided in the Phase II Plan.

Master Plan: Includes in addition to existing system the roads metalled and unmetalled provided in the Master Plan.



Comparison of existing system, Phase II Plan and Master Plan

PLATE I

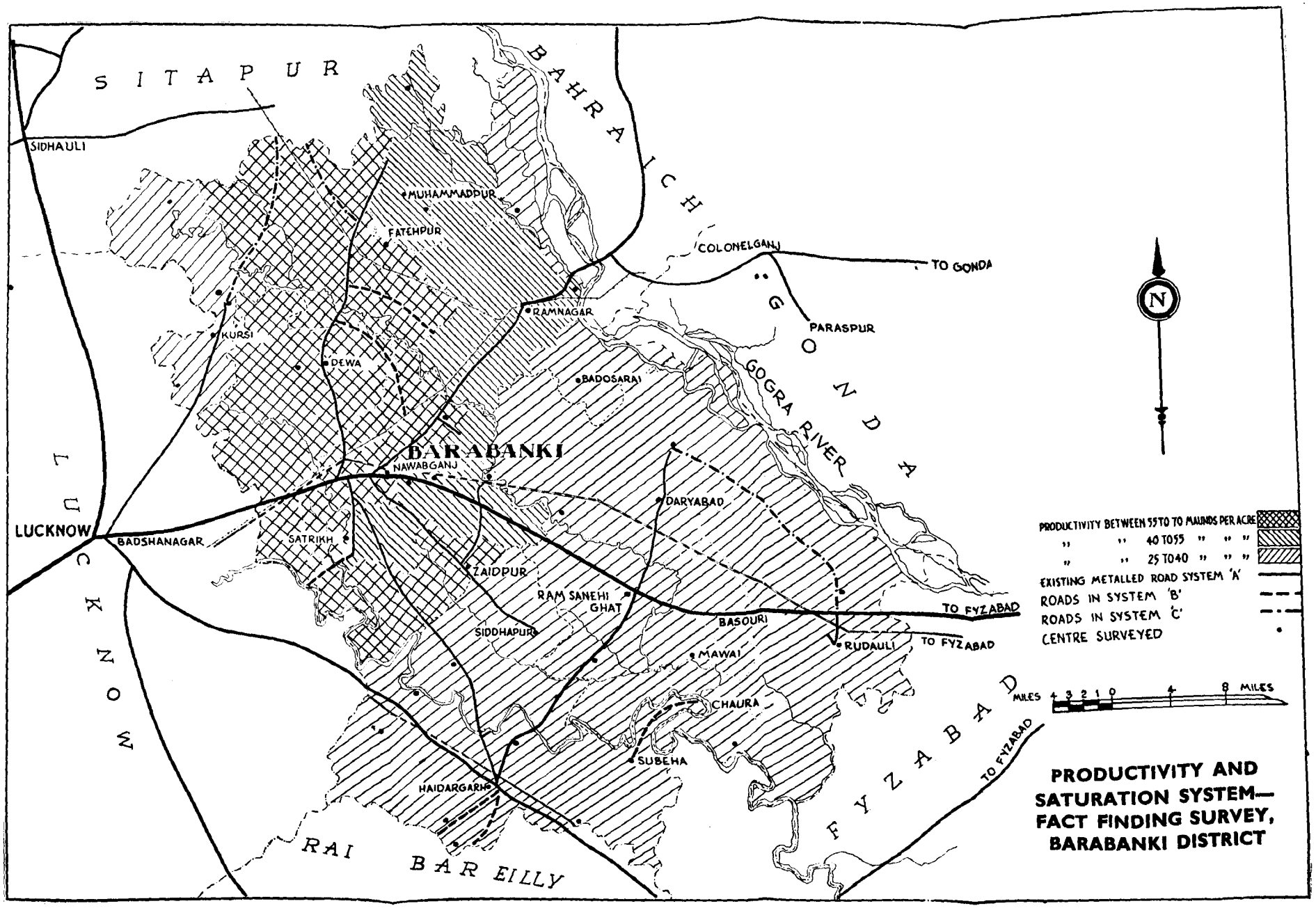
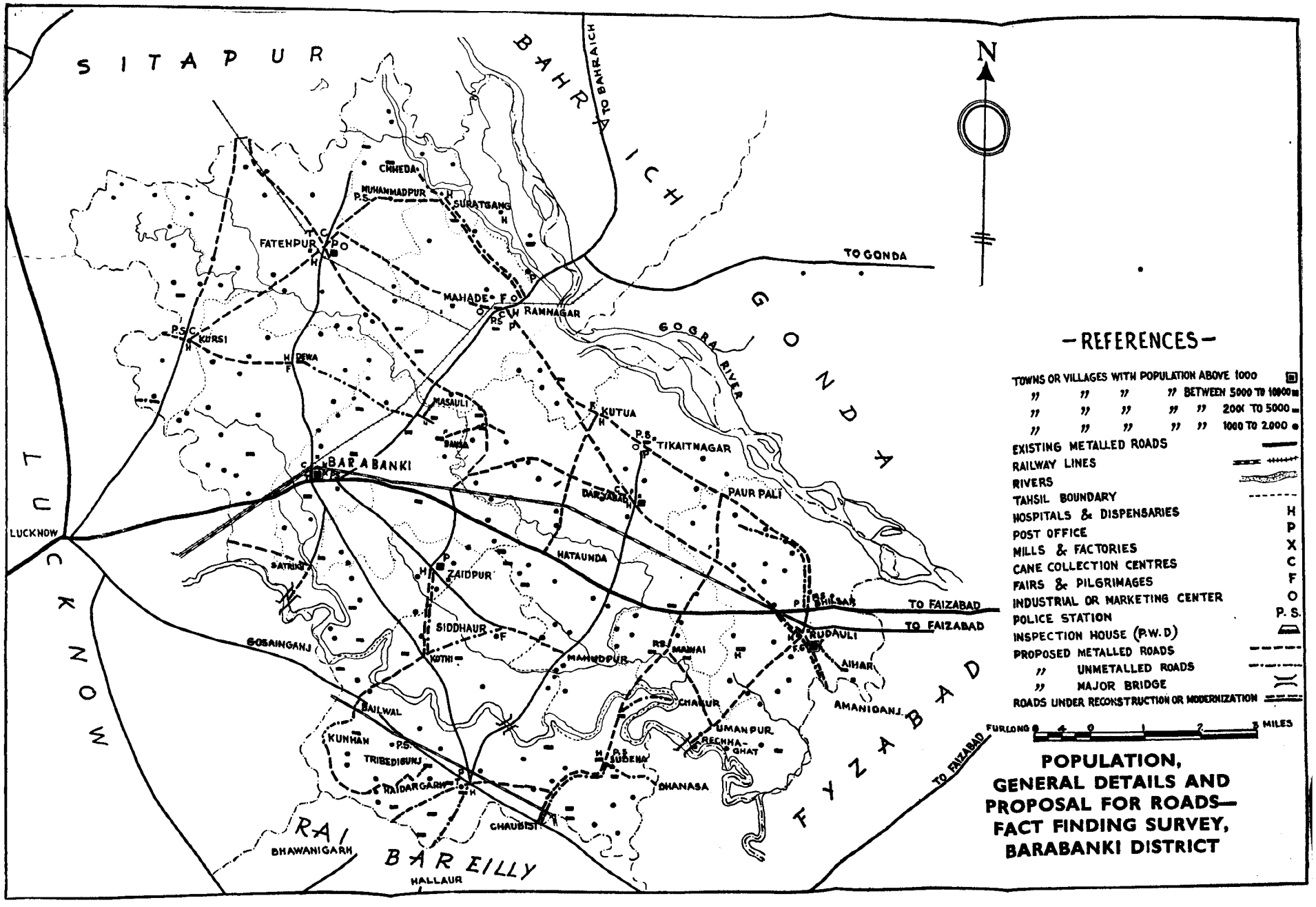

SITAPUR
BAHRAICH
SIDHAULI
MUHAMMADPUR
FATEHPUR
COLONELGANJ
TO GONDA
RAMNAGAR
PARASPUR
KURSI
DEWA
BADOSARAI
GOGRA RIVER
GONDA
BARABANKI
NAWABGANJ
DARYABAD
LUCKNOW
BADSHANAGAR
SATRIKH
ZAIDPUR
RAM SANEHI GHAT
TO FYZABAD
BASOURI
SIDDHAPUR
RUDAULI
TO FYZABAD
MAWAI
CHAURA
SUBEHA
HAIDARGARH
TO FYZABAD
FYZABAD
RAI BAR EILLY
PRODUCTIVITY BETWEEN 55 TO 70 MAUNDS PER ACRE
" " 40 TO 55 " " "
" " 25 TO 40 " " "
EXISTING METALLED ROAD SYSTEM 'A'
ROADS IN SYSTEM 'B'
ROADS IN SYSTEM 'C'
CENTRE SURVEYED
MILES 4 3 2 1 0 4 8 MILES
N
PRODUCTIVITY AND SATURATION SYSTEM— FACT FINDING SURVEY, BARABANKI DISTRICT

PLATE II


SITAPUR
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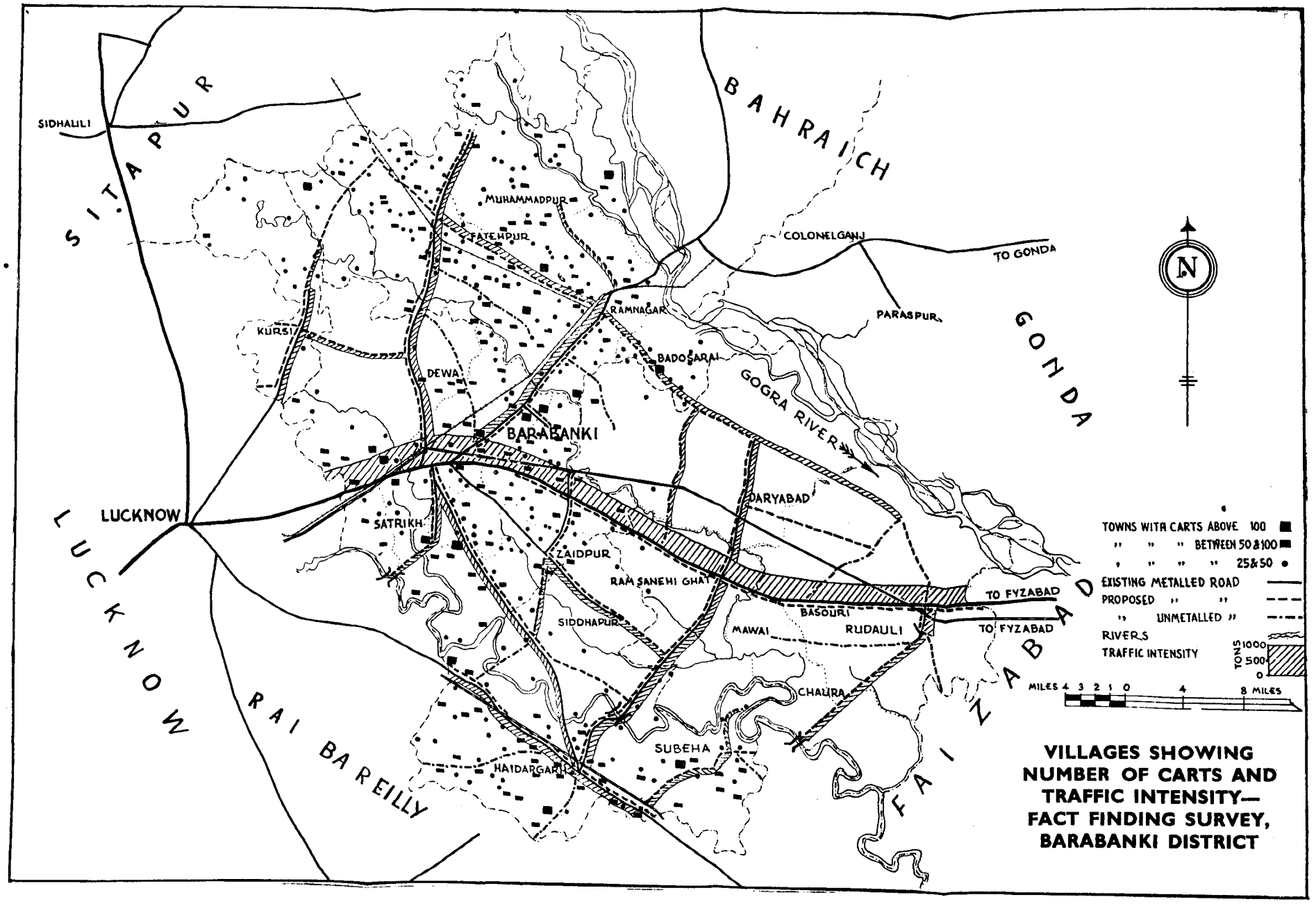
TO BAHRAICH
LUCKNOW
GONDA
FYZABAD
RAI BAREILLY
N
TO GONDA
TO FAIZABAD
TO FAIZABAD
TO FAIZABAD
CHHEDA
MUHAMMADPUR
P.S.
SURATGANJ
FATEHPUR
MAHADEO
RAMNAGAR
GOGRA RIVER
KURSI
P.S.
DEWA
MASAULI
KUTUA
P.S.
TIKAITNAGAR
BARABANKI
DARIYABAD
PAUR PALI
HATAUNDA
SATRIKH
ZAIDPUR
SIDDHAUR
GOSAINGANJ
KOTHI
MAHMUDPUR
RS.
MAWAI
SHIVGAR
RUDAULI
AIHAR
AMANGANJ
CHAKUR
UMANPUR
RECHNA-GHAT
BAILWAL
KUNHAN
P.S.
TRIBEDIGUNJ
HAIDARGARH
P.S.
SUBEHA
DHANASA
CHAUBISI
BHAWANIGARH
HALLAUR
-REFERENCES-
TOWNS OR VILLAGES WITH POPULATION ABOVE 1000
" " " " BETWEEN 5000 TO 10000
" " " " " 2000 TO 5000
" " " " " 1000 TO 2000
EXISTING METALLED ROADS
RAILWAY LINES
RIVERS
TAHSIL BOUNDARY
HOSPITALS & DISPENSARIES H
POST OFFICE P
MILLS & FACTORIES X
CANE COLLECTION CENTRES C
FAIRS & PILGRIMAGES F
INDUSTRIAL OR MARKETING CENTER O
POLICE STATION P. S.
INSPECTION HOUSE (P.W.D)
PROPOSED METALLED ROADS
" UNMETALLED ROADS
" MAJOR BRIDGE
ROADS UNDER RECONSTRUCTION OR MODERNIZATION
FURLONG 0 4 0 1 2 3 MILES
POPULATION, GENERAL DETAILS AND PROPOSAL FOR ROADS— FACT FINDING SURVEY, BARABANKI DISTRICT

PLATE III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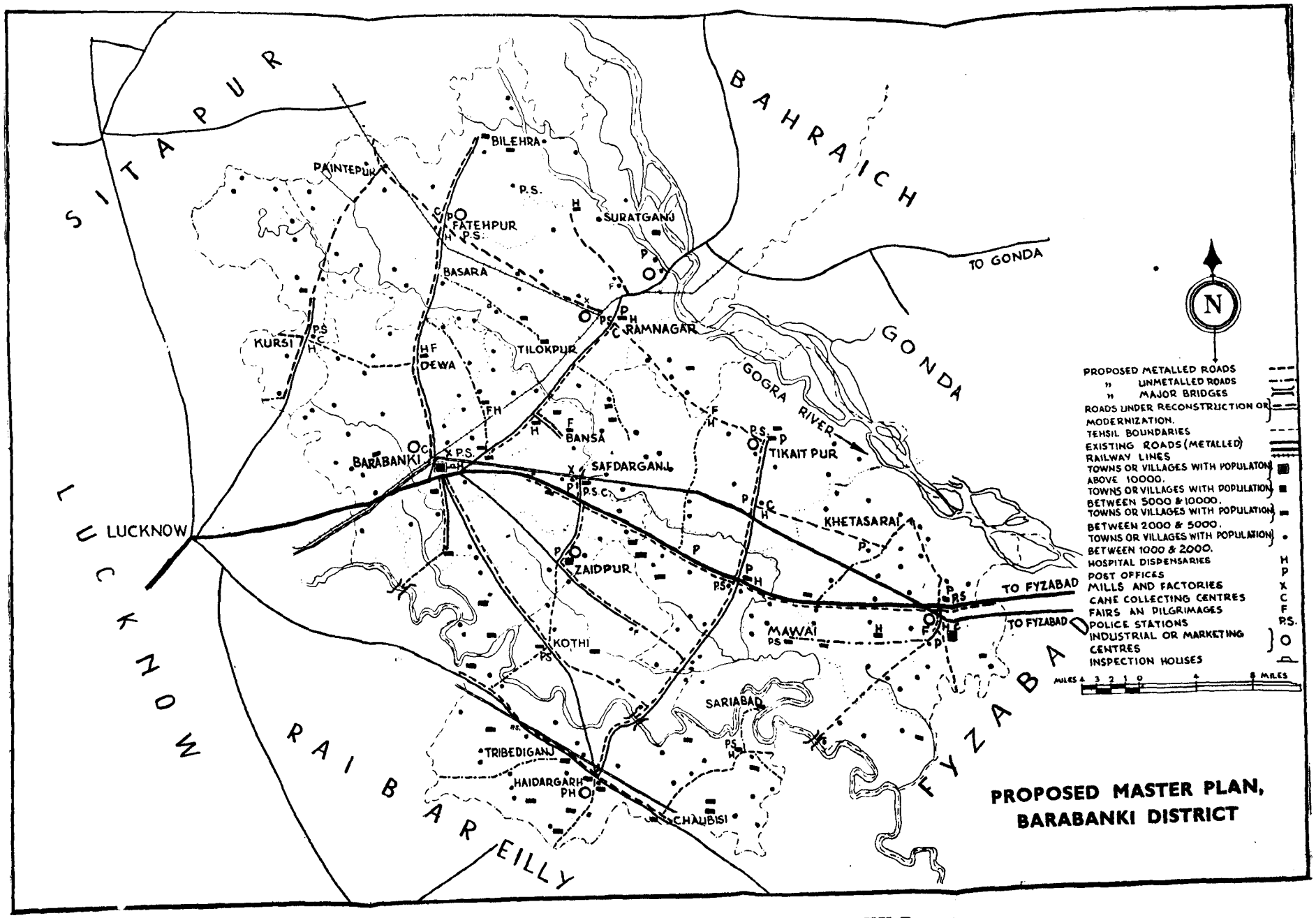
BASOURI
SIDDHAUR
MAWAI
RUDAULI
TO FYZABAD
FAIZABAD
CHAURA
SUBEHA
HAIDARGARH
RAI BAREILLY
N
TOWNS WITH CARTS ABOVE 100
" " " BETWEEN 50 & 100
" " " " 25 & 50
EXISTING METALLED ROAD
PROPOSED " "
" UNMETALLED "
RIVERS
TRAFFIC INTENSITY
TONS 1000 500 0
MILES 4 3 2 1 0 4 8 MILES
VILLAGES SHOWING NUMBER OF CARTS AND TRAFFIC INTENSITY— FACT FINDING SURVEY, BARABANKI DISTRICT

PLATE IV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BILEHRA
PAINTEPUR
P.S.
FATEHPUR
P.S.
SURATGANJ
BASARA
RAMNAGAR
KURSI
DEWA
TILOKPUR
BANSA
GOGRA RIVER
TIKAIT PUR
BARABANKI
SAFDARGANJ
P.S.C.
KHETASARAI
ZAIDPUR
MAWAI
KOTHI
SARIABAD
TRIBEDIGANJ
HAIDARGARH
CHAUBISI
N
PROPOSED METALLED ROADS
" UNMETALLED ROADS
" MAJOR BRIDGES
ROADS UNDER RECONSTRUCTION OR MODERNIZATION.
TEHSIL BOUNDARIES
EXISTING ROADS (METALLED)
RAILWAY LINES
TOWNS OR VILLAGES WITH POPULATON ABOVE 10000.
TOWNS OR VILLAGES WITH POPULATION BETWEEN 5000 & 10000.
TOWNS OR VILLAGES WITH POPULATION BETWEEN 2000 & 5000.
TOWNS OR VILLAGES WITH POPULATION BETWEEN 1000 & 2000.
HOSPITAL DISPENSARIES
POST OFFICES
MILLS AND FACTORIES
CANE COLLECTING CENTRES
FAIRS AN PILGRIMAGES
POLICE STATIONS
INDUSTRIAL OR MARKETING CENTRES
INSPECTION HOUSES
H P X C F P.S. O
MILES 4 3 2 1 0 4 8 MILES
PROPOSED MASTER PLAN, BARABANKI DISTRICT

Paper No. 187

"THE IMPORTANCE OF TRAFFIC ENGINEERING IN INDIA"

By

DR. R. K. N. IYENGAR, B.E., D.Sc., M.I.E. (INDIA).

CONTENTS

SYNOPSIS

The main object of this Paper is to focus attention on the need for adopting modern methods to reduce accidents on roads.

The Paper describes the traffic conditions obtaining on the roads in India. A survey of the growth of motor and animal-drawn vehicles, traffic conditions, accidents and the methods adopted for accident prevention in six big cities is made. Some suggestions to regulate traffic and minimise hazards on roads are made.

1. INTRODUCTION

1.1. Traffic engineering is "that phase of engineering which deals with the planning and geometric designs of streets, highways and abutting lands, and with traffic operation thereon, as their use is related to the safe, convenient and economic transportation of persons and goods." It covers a very vast field and its scope extends to various subjects such as road accidents, traffic surveys for obtaining details of traffic conditions, traffic planning, geometric design of roads and intersections of all types, sight distances, traffic capacity studies, surface characteristics and their influence on speed and accidents, design and location of

traffic control devices, parking, street lighting and traffic regulations etc.

1.2. Due to the greater use of motor vehicles there has been an increase in road traffic in recent times. Traffic engineering methods will help in providing a smooth traffic flow conducive to safer and quicker transportation of men and materials, so vital to the economic life and quicker tempo of industrialisation and in reducing human sufferings and loss to property, by building safety into the roads. There is a great necessity in India to make a systematic study of the existing traffic conditions and adopt suitable engineering methods. Education of the road users and enforcement of traffic rules are also necessary for minimising accidents. This Paper touches upon the salient points only as far as India is concerned and stresses the importance of (1) maintaining proper records of types and behaviour of road users and accidents, etc. and the advantage of providing improved designs and layout of roads using results of research, (2) widespread educational propaganda and (3) stricter enforcement measures.

2. TRAFFIC CONDITIONS IN INDIA

2.1. The number of motor vehicles has increased nearly two fold since 1940, Table 1.

TABLE 1

Year ending 31st March	Total number of motor vehicles
1941	164,886
1942	156,822
1943	154,284
1944	162,247
1945	178,697
1946	181,621
1947	211,949
1948	225,227
1949	269,669
1950	294,727
1951	307,157

2.2. Behaviour of Traffic on Highways

Mixed traffic consisting of fast moving cars, buses and trucks, slow-moving bullock carts, horse and camel drawn vehicles, cycles, rickshaws, and sometimes herds of cattle and sheep, use the highways. In some States the speed of heavily-loaded passenger buses and lorries plying on the highways connecting important cities is restricted to 15-20 miles per hour. But enforcement of these rules is rather slack except at some check posts, perhaps due to paucity of police staff. Speeding is the order of the day and is a potential source of danger on the highways.

Slow-moving traffic do not leave the hard metalled surface and thus cause difficulties to the fast traffic while overtaking them.

Loading of carts with projecting grass, hay, sugar-cane, or logs of timber etc., obstruct the view of motorists and is, therefore, dangerous especially when these carts move along in caravans during nights without any lights.

From a random survey, it was observed that more than 50 per cent of the bullock cart drivers are either sleeping or resting during night journeys, allowing the bullocks to slowly jog along.

While private owned cars generally have proper head and tail lights, quite a good number of trucks run without tail lights or have badly aligned headlights, which are also undipped. The proverbial speeding habits of truck drivers coupled with improper lights cause hazards in night travel.

A great number of cyclists travel without lights and tail reflectors.

In general, there is no traffic control and enforcement of rules in the real sense on the highway. Conditions on minor roads are worse.

Due to the increasing menace of road accidents in recent times, the Govt. of India and many States such as Bombay, Bengal and Madras have published Highway Safety and Road Traffic Codes, laying down suitable regulations for control of transport vehicles, traffic signs and signals, parking motor buses and cars, and rules to be observed on roads. Regional Transport Authorities and Road Traffic Boards are set up in several States and major cities, for deciding disputed matters regarding road traffic and transportation.

Reckless driving and speeding is resorted to mostly by drivers of buses, lorries and taxis.

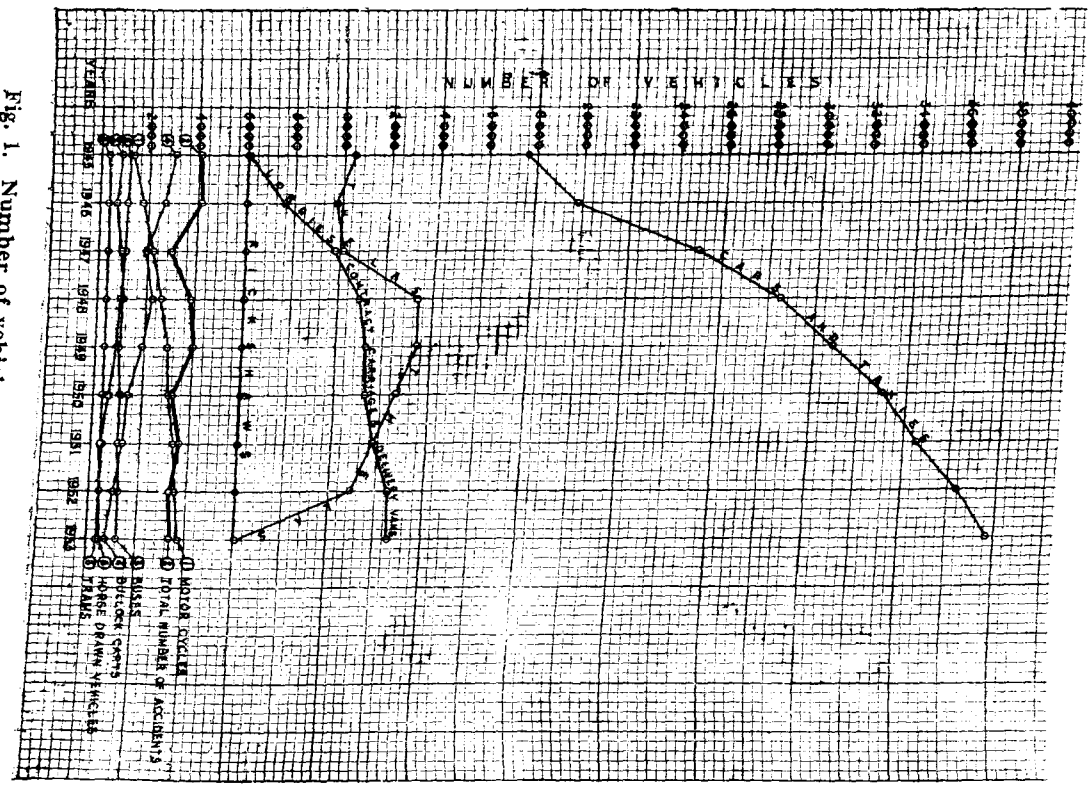

Fig. 1. Number of vehicles and accidents in Calcutta,

TABLE 2

Number of Vehicles and Accidents in Calcutta

	Year								
	1945	1946	1947	1948	1949	1950	1951	1952	1953
Vehicles									
Private Cars & Taxis ...	17,596	19,818	25,000	28,472	30,819	32,973	34,532	36,393	37,640
Lorries ...	5,339	6,722	8,771	9,700	9,999	9,999	10,283	10,991	10,994
Contract Carriages ...	422	499	594	674	725	766	788	803	818
Delivery Vans ...	334	360	464	558	590	615	680	733	793
Trailors ...	133	250	409	471	497	521	561	587	633
Tractors ...	17	19	20	23	27	29	39	42	65
Buses ...	833	686	900	1,033	1,078	1,104	1,129	1,214	1,218
Motor Cycles ...	1,305	1,758	2,230	2,644	2,919	3,091	3,318	3,526	3,691
Hackney Carriages ...	1,217	1,110	991	990	919	622	417	417	417
Rickshaws ...	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Animal-drawn Vehicles	3,048	2,710	1,991	2,230	1,978	1,442	1,282	1,052	796
Hand Carts ...	10,030	9,718	10,064	13,419	13,419	12,673	11,754	10,981	6,010
Trams ...	369	381	388	395	395	395	425	425	425
Total ...	46,643	50,031	57,819	66,609	69,365	70,230	71,208	73,164	69,500
Number of persons involved in road accidents									
Injured ...	3,743	2,974	2,847	3,722	3,861	3,135	3,518	3,203	3,246
Killed ...	328	225	184	111	145	83	71	84	102
Light signals for controlling traffic									
Automatic ...	—	—	—	—	—	—	6	—	9
Hand Operated ...	4*	4	4	5	5	6**	6	6	4

* One of these lights has been made automatic in 1953.

** One made automatic in 1953.

Calcutta traffic police Authorities are always on the alert and due to proper system of traffic control, introduction of some automatic light signals for controlling road traffic at important road junctions, the number of traffic casualities is gradually decreasing. Inspite of a better traffic control and enforcement and also a reasonable road sense amongst the public, it has been noticed that the queue system at bus and tram stands has not been working satisfactorily and many accidents have occurred when people fight to board a moving vehicle. Though the Calcutta Corporation have passed a resolution as early as 1952 in favour of formation of orderly queues and its enforcement by the police, the situation has not improved much. Propaganda about the necessity for a better civic sense and stricter enforcement methods are indicated.

The Calcutta police have in recent years undertaken an extensive programme of marking the centre line of roads with " crystallex " plastic white lines so that vehicles could keep to the proper road lanes. These plastic marks reflect the light better at night as each yard contains nearly a million ' glass spheres '.

There are very few round-abouts in Calcutta due to very heavy expenditure that has to be incurred in acquiring land in busy localities, but traffic is well controlled at road intersections either by traffic police or traffic light signals.

Calcutta is far ahead in traffic training methods, as the police Department has established a ' Police Traffic Training School ' in 1952. in order to train personnel in advanced traffic control to cope with the growing complexities of the city's traffic requirements. This school also offers refresher courses for keeping up a continuity of the training. It is understood that in one year, 500 officers and men of the Calcutta and West Bengal police, military police, from Delhi and other parts of India passed through the school.

The Safety First Association of India, Bengal Branch in co-operation with the Calcutta police and Govt. Publicity Department arrange ' Safety First Weeks ' and ' Safety Exhibitions ' with special features like ' Learning Through Play ' for children to acquaint them with the basic principles of road safety, to watch the behaviour of road users and inculcate a proper road sense in them. Further, the Association have published the Highway Code in Bengali and distributed them free to every school and other organisations to create interest in road safety. They have also collected much data through complaint post-cards from which suitable plans have been formulated and got approved by the

Photo 1. **Impediments to free flow by animal-drawn traffic in a main street.**

Photo 2. **Mix up of slow traffic occupying most of the road.**

Photo 3. **Parking of 'thelas' and unloading at the roadside takes away much of the effective road width.**

Photo 4. **Two bus stops opposite each other blocks the entire road.**

Photo 5. **Stray cattle in a main city street cause traffic bottleneck.**

Photo 6. **Confusing speed and parking sign.**

Photo 7. **Enforcement during peak hours leads to orderly traffic flow.**

Photo 10. **Pillonriding cyclists are a menace to road traffic.**

Photo 8. **Traffic mix up caused by non-observance of road rules.**

Photo 11. **Heavily-loaded cyclists.**

Photo 9. **Cyclists riding many abreast.**

Photo 12. **Bullock carts Heavily-loaded with bulk produce require large road width.**

Photo 13. Slow-moving vehicles occupy most of the carriageway on a broad road.

Photo 14. **Mixed traffic with kerb parking impedes smooth traffic.**

Photo 15. **Bad parking habits lead to traffic delays.**

Photo 16. **Herd of cattle in the middle of road obstructs traffic.**

Photo 17. **Centre line markings help orderly traffic.**

Photo 18. **Jay walking in main street.**

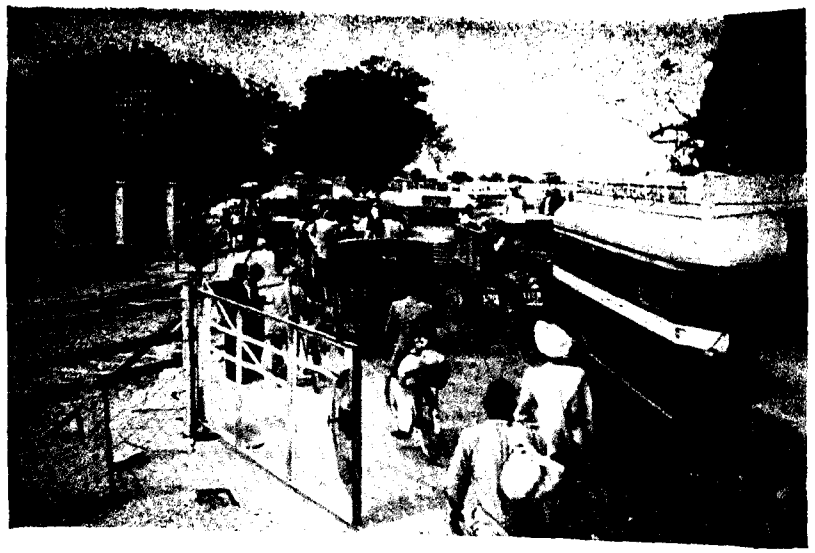

Photo 19. Traffic Jam at a road—rail level crossing.

Photo 20. Rush of cycle traffic during peak hour—New Delhi.

Traffic Advisory Committee. All these have resulted in better road usage and better lighting in the city.

Calcutta's system of maintaining detailed statistics regarding vehicles and road accidents is very good and has been helpful in achieving many an improvement in traffic conditions.

2.6. Bombay

Bombay had a population of 28.4 lakhs in 1951. The number of motor vehicles is on the increase, whereas animal and hand-drawn vehicles are on the decrease, Table 3 and Fig. 2.

Bombay has about 14.0 motor vehicles per 1,000 population and road fatalities in 1951 were 9.2 per lakh of population which compare well with similar cities. But the city's 660 deaths per lakh of vehicles are more than anywhere else in the world. The number of injured which is 184.3 per lakh of persons is quite high, as also the 131.7 injuries per 1,000 vehicles. The city's toll of 182.22 children killed per 1,00,000 vehicles is very high compared to other major cities in the world.

Bombay has many good roads running through busy shopping centres. Traffic control at important road junctions especially during peak hours is of a very high standard compared to that in other Indian cities. There are no automatic traffic light signals, but it is understood that due to very heavy intensity of traffic, it is proposed to instal a few of them at busy junctions as an experimental measure. Round-abouts are few compared to Delhi.

TABLE 3

Number of Vehicles and Accidents in Bombay

Year	No. of registered motor vehicles	No. of registered bullock carts & 'thelas'	No. of registered horse-drawn vehicles	No. of cycles	Persons involved in road accidents	
					No. injured	No. killed
1950	30,403	1288	2423	Not available	5912	227
1951	35,561	1049	2102	do	5234	262
1952	35,345	883	1623	do	4494	221
1953	36,081	1190	1403	do	4409	216

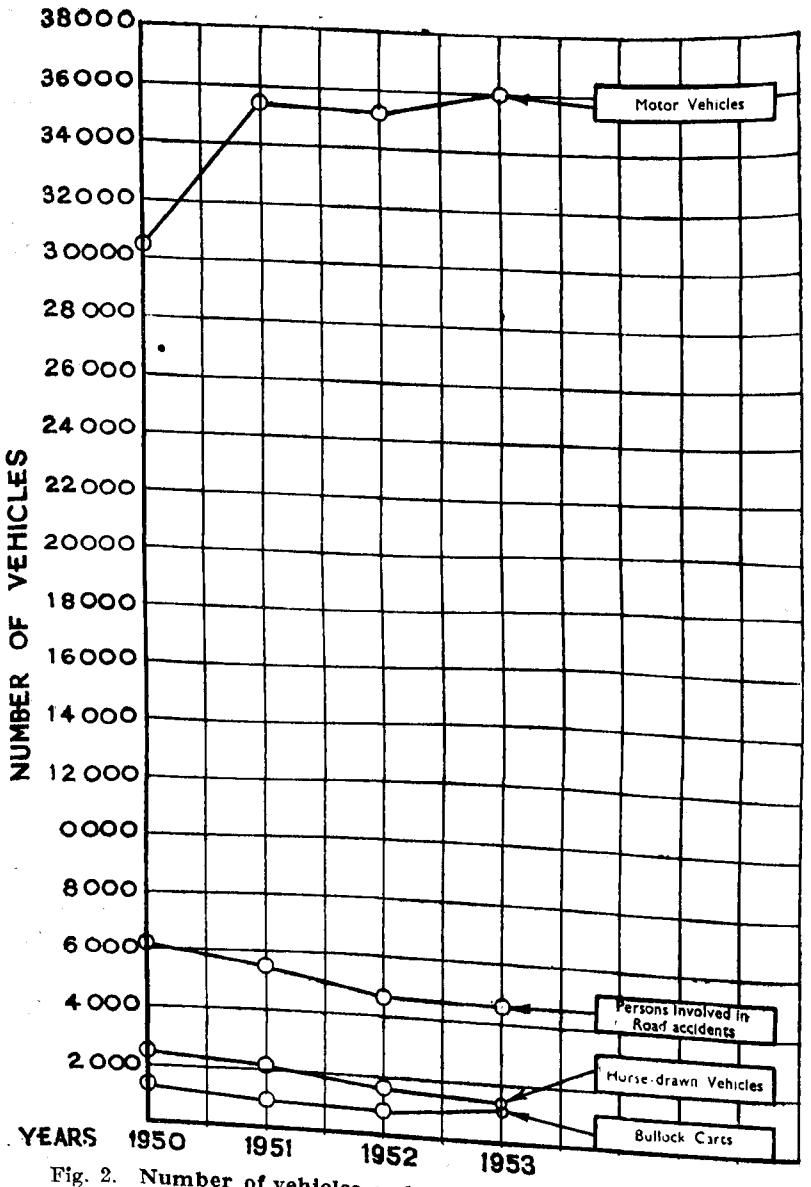

Fig. 2. Number of vehicles and accidents in Greater Bombay.

The taxi, bus and tram services are very well organised having frequencies to suit the traffic requirements. The greatest 'outlaws' against traffic rules are the jay walkers, horse-drawn gharries (victoria) and bullock carts. As the pedestrian traffic during office hours is terrific, great care is taken by traffic police to channelise movement at the numerous road crossings and in forcing pedestrains to use the footpaths.

"Silence zones" have been introduced in the fort area and at other places, and they have proved to be a far greater success than anticipated due to the strong road sense displayed. Incidentally this has done more to get rid of jay walkers than any other measure adopted so far.

The Traffic Control Department of Bombay has also introduced traffic control twice a week at selected centres by school boys between the ages of 10 and 12 belonging to a local school situated in a very crowded locality. After six months' training, the boys are examined and certificates are awarded to successful boys. The best trainee is presented with a medal.

"Traffic Safety Weeks" are organised by the Western India Automobile Association in co-operation with the Police Department. Placards and banners bearing such slogans as 'Traffic accidents do not happen—they are caused', and 'Your First Accident may be Your Last' are exhibited. These along with lectures, film shows, and on-the-spot instructions on road safety in various areas of the city, have been helpful in making people road conscious. The Association has also organised 'reliability trials' for motor vehicles on a 161-mile route from Poona to Ahmednagar, 'rough driving and reversing tests' for finding out the roadworthiness of vehicles under normal driving conditions.

On the whole, it can be said that traffic congestion and accident rate are gradually being brought under control by earnest efforts on the part of the traffic police, organizations such as the Western India Automobile Association with the co-operation of the road users.

2.7. Madras

Madras with a population of 14.3 lakhs is growing rapidly due to expansion of many industries. Motor vehicles are on the increase. The number of animal-drawn vehicles is decreasing. The number of road accidents is on the increase, Table 4 and Fig. 3, Plate I.

TABLE 4

Number of Vehicles and Accidents in Madras

	Year									
	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954
Types of Vehicles										
Motor Cars	3,856	3,877	5,656	7,160	7,248	8,094	7,641	9,166	7,221	8,008
Lorries	1,019	1,050	1,711	1,462	1,306	1,272	1,371	1,325	1,349	1,444
Buses	334	418	611	599	525	474	484	492	501	582
Taxis	174	156	263	290	256	272	382	320	270	296
Motor Cycles	465	652	973	1,278	1,117	1,089	1,226	1,413	1,345	1,431
Bullock Carts and Thelas	—	—	—	585	529	408	431	425	372	368
Rickshaws	4,216	5,010	5,118	4,750	4,250	3,750	3,250	2,750	2,250	3,750
Horse-drawn Vehicles	—	—	—	526	527	373	407	425	373	355
Cycles	Not Available									
Persons involved in Accidents	2,286	2,299	2,368	2,044	2,684	2,649	2,953	2,903	2,511	2,690
Injured	2,221	2,254	2,313	2,002	2,645	2,607	2,886	2,842	2,449	2,636
Killed	65	45	55	42	39	42	67	61	62	54

Many of the main roads of Madras are well designed and broad. Bus services run at very frequent intervals. Rickshaws provide a quick means of transport for short distance travellers.

Traffic control and enforcement in Madras can be considered as fairly good. But due to the heavy mixed traffic and the rapid increase in population, there have been frequent bottlenecks and the accident rate is increasing. The number of motor vehicles in Madras is very low, being only 8 per 1,000 people. Fatal accidents were 4.69 per lakh of population in 1951. 603 deaths per lakh of vehicles are larger than in any city in the world except Bombay with its 635 persons injured on the roads are 202 per lakh of population and this is very high compared to other cities. The number of children, killed on the roads is also very high and is 137.90 per one lakh vehicles and is exceeded only by Bombay's 182.22. Madras has very few prosecutions for intoxicated driving to its credit which is perhaps due to prohibition in force.

It has been noticed that a high incidence of accidents is due to motor cars and cyclists, the next in order being buses and lorries. The number of accidents per vehicle per 1000 miles travelled for different types of vehicles is given in Table 5.

TABLE 5

Accident rate in Madras

Type of vehicle	Monthly average No. of accidents	No. of vehicles	Average monthly distance travelled by one vehicle	Accident per vehicle per 1,000 miles
Cars	101	6,670	1,000	0.0152
Motor cycles	14	890	1,000	0.0157
Buses	33	378	3,000	0.0291
Lorries	31	1,008	1,500	0.0205
Taxis	10	205	1,500	0.0195
Trams	24	102	3,000	0.0783
Pedal cycles	50	32,649	250	0.00613
Pedal cycles	500			0.0613

Zebra pedestrian crossings have been provided. Traffic surveys and accident counts have been taken at important road junctions and suitable round-abouts have been constructed, resulting in a smoother traffic flow. Recently an automatic light signal has been installed at one junction and it has been helpful for controlling traffic at peak hours. The Corporation of Madras has undertaken the preparation of a master plan for the city and its environ in which the city's traffic problem will be dealt with. The traffic hold-up during the recent Congress session in January 1955 at Avadi has been an eye-opener to the concerned authorities.

2.8. Delhi

The population of Delhi had increased to four times its prewar size and was 17.4 lakhs in 1951. The motor vehicles also shows a steep rise, especially lorries, taxis and motor cycle rickshaws. While the numbers of bullock carts, tongas etc. show a gradual decline, the number of hand-carts is increasing. The most phenomenal rise is shown in the number of cycles. Though the statistics indicate that there are about 1,22,000 cycles in Delhi, this figure would definitely be more than two lakhs as quite a good number of cycles have not been registered.

Traffic has increased more than three-fold; for example, 1295.9 tons was the traffic using Mathura road in 1934 whereas in 1954-55 it was 4,800 tons.

Details of vehicles by type and the number of accidents are given in the Table 6, Fig. 4, Plate I. Table 7 shows the peak hour flow at a selected place.

At important shopping and business centres there is insufficient parking space, leading to jay parking of vehicles, traffic jams and accidents. During peak hours it is quite common to see motor vehicles overcrowding the foot-paths and monopolising them as parking places. Of late, the authorities have allocated existing suitable places for parking of cars. In a busy shopping area (Chandni Chowk) where trams ply, motor cars are parked on both sides throughout the day for want of a suitable off-street space. Also in the heart of commercial Delhi, the parking position is most unsatisfactory as hundreds of lorries are parked from end to end of the street even blocking entrances to lanes, resulting in great confusion and increasing hazard to road safety.

TABLE 6

Number of Vehicles and Accidents in Delhi

	1948	1949	1950	1951	1952	1953	1954
Motor Cycles ...	1,832	2,109	2,423	2,486	2,502	2,843	2,942
Lorries ...	748	1,307	1,473	1,510	1,709	2,021	1,969
Taxis & motor cycle rickshaws ...	213	196	351	561	634	952	968
Buses ...	383	390	440	494	562	627	731
Cars ...	6,461	6,856	7,126	7,404	7,582	7,945	8,307
Total ...	9,637	10,858	11,813	12,455	12,989	14,388	14,917
Hand carts ...	575	988	1,162	1,381	1,452	1,700	1,964
Bullock carts ...	1,763	1,795	1,872	1,806	1,485	1,370	1,525
Tongas ...	3,311	4,510	3,871	2,223	2,948	2,576	2,781
Kharkhras ...	1,109	1,528	1,298	1,056	937	963	978
Tum Tums ...	83	144	102	86	15	12	11
Cycle Rikshaws ...	250	400	600	600	600	600	600
Cycles ...	—	—	—	—	99,539	119,873	121,796
Total No. of accidents	281	293	658	684	303	972	925
Persons killed ...	58	32	72	93	68	85	72
Persons injured ...	209	204	459	398	302	517	612

TABLE 7

Peak Hour Flow in Delhi

Type of traffic	Numbers
Horse-drawn vehicles	213
Other animal-drawn vehicles	34
Motor cars	336
Motor cycles	59
Lorries	57
Buses	89
Hand carts	15
Rickshaws	27
Cycles	1612

The number of the accidents on some of important roads are given in Table 8. In addition to these, 69 accidents occurred at road junctions. These places mentioned in the Table require special attention.

TABLE 8

The number of accidents in the period 1946—1948

Road	No. of accidents
Mehrauli Road to Alipore Road via Prithviraj Road, Shahjahan Road, Hardinge Avenue, Elgin Road and Lothian Road	131
Mathura Road — Wellesley Road — Curzon Road	41
Queensway	33
Parliament Street—Minto Road	50
Lady Hardinge Road	8
Irwin Road	18
Reading Road	14
Panchkuin Road	45
Chelmsford Road	21
G. B. Road	26
Delhi–Shahdara Road (Grand Trunk Road)	22
Total	409

An enumeration during peak hour traffic in Connaught Place area, showed that 1,000 to 1,200 motor vehicles and thousands of cycles are parked. Except in the inner circle, these vehicles are mostly parked in a disorderly manner without observing the rule of 'facing the road,' resulting in impediments to smooth traffic flow. It is suggested that further parking facilities be provided for another 500 cars by utilising part of the extensive central park and the lawns opposite Regal Buildings.

The authorities are alive to the increasing traffic needs and construction of rotaries designed to modern standards, silence zones, and marking of pedestrian crossings etc. have been done.

As an experimental measure, two electrically-operated traffic signals have been installed. Of late, traffic regulations are tightened up by periodical surprise checks and prosecutions for offences such as crossing the 'stop line' using illegible number plates, defective tail lights and exceeding speed limits. In addition to posting traffic constables at important crossings, 70 specially trained constables wearing 'May I Help You' badges are posted at railway station, congested crossings, busy shopping centres and cinema houses, to help children, the old and infirm and others during difficulties on the road. These measures have been very useful.

Much interest is evinced in this problem by the traffic police of Delhi State and non-official organizations such as the Automobile Association of Upper India, National Safety Association, Rotary Club, Road Courtesy Squad, Scouts and National Cadet Corps. 'Road Safety Week', 'Walk on Footpath Campaign' for educating the road users and the public on the proper observance of road laws, popular lectures and film shows are arranged and leaflets on safety code are distributed.

These periodical checks have had no effect. Continuous enforcement with greater vigour by prosecutions and heavy fines, by introducing permanent checking arrangements seems necessary. Movements of flocks of cattle on many of the roads must be prevented by diverting them to lanes and unfrequented routes.

2.9. Hyderabad

The number of motor vehicles, animal-drawn vehicles and accidents in the city are given in Table 9 and Fig. 5, Plate I. The number of animal-drawn vehicles is on the decrease whereas cycles and cycle rickshaws are on the increase. The number of accidents is on the increase. The number of cycle rickshaws have increased more than two fold within the last six years and extra traffic police are posted during peak hours to control their reckless movement.

2.10. Bangalore

The city's population of 7.8 lakhs in 1951 is rapidly increasing due to industrial expansion.

TABLE 9

Number of Vehicles and Accidents in Hyderabad

—	Year						
	1946	1947	1948	1949	1950	1951	1952	1953	1954
Types of Vehicles									
Motor Cars, Trucks, Buses ...	—	—	2,599	2,749	3,263	6,258	7,183	7,203	6,079
Motor Cycles ...	—	—	464	422	519	1,035	1,709	1,780	1,625
Horse-drawn Vehicles ...	1,163	893	820	503	478	453	308	217	—
Bullock-carts ...	2,676	2,305	2,632	2,297	1,992	2,176	2,279	2,169	—
Cycles ...	37,278	38,471	38,106	44,352	42,777	49,041	51,825	53,725	—
Rickshaws ...	3,460	3,457	2,621	3,705	5,003	5,481	6,479	7,275	—
Persons involved in Accidents									
Injured ...	— Not available					211	347	362	345
Killed ...	— Not available —					7	18	18	21

Cycles are popular amongst factory workers, students and the middle class population and have registered the maximum rise. The number of road accidents is fairly high. At all main road crossings and turnings, 'Halt' boards and 'Slow Down' road signals have been put up. At these places vehicles must stop for a few seconds and then only proceed whether a policeman is on duty or not. This prevents motorists from speeding and gives them a second or two to look round whether there is any danger from approaching traffic. This has resulted in a reduction of accidents in recent years.

Photos 1 to 20 illustrate some of the points mentioned above.

3. TRAFFIC ENGINEERING METHODS IN ADVANCED COUNTRIES

3.1. In progressive countries like the U.S.A. and the U. K., considerable thought is given to traffic planning and road safety and efforts are being made to reduce accidents on the roads from all possible angles. Organizations for obtaining statistical data on road traffic and keeping records of the data collected exist. Improved designs and specifications of roads and crossings, parking places, and road signs and signals have been worked out and adopted.

3.2. Fast and slow-moving traffic have been separated; centre line markings are provided on an extensive scale. Greatest value has been attached to the education of the road users and public on proper road use. Suitable traffic laws have been framed and very rigidly enforced. Traffic engineering departments have been established which work in closest co-operation with all agencies—government and non-official—including education and research institutions. All these measures have resulted in a high degree of efficiency and economy in road traffic and transportation. It is neither possible nor economically feasible for at least some years to come to adopt all the latest methods practised abroad in India.

4. SUGGESTIONS FOR REGULATION OF TRAFFIC AND ACCIDENT PREVENTION

4.1. In India various Government and private organizations such as Automobile, Rotary and Safety First Associations are doing valuable work to minimise accidents. But co-ordinated effort is lacking.

While in the U.S.A. and the U. K. pneumatic-tyred high-speed vehicles predominate—60 millions in the U. S. A. and about 6 millions in the U. K., in India traffic consisting of automobiles, slow moving bullock and horse carts, and cycles have to be catered for. In order to avoid greater traffic hazards and achieve better use of motor vehicles, separate lanes should be earmarked for fast and slow-moving vehicles on roads which are wide enough. The kutcha road berms on highways in rural areas should be made pucca though not to the highest specification, in stages, and set apart exclusively for animal-drawn vehicles and cycles. Concrete trackways must be constructed wherever feasible for animal-drawn vehicles. All these may entail greater initial costs, but this will be far outweighed by the resultant economy.

4.2. Traffic Surveys and Research

As a pre-requisite for all new road projects and programme of road improvements, whether in rural or urban areas, traffic surveys including origin-destination studies by the interview method or pre-paid postcards or roadside interviews must be carried out, results statistically analysed and future trends in the growth taken into account in the design. 'Before and After Studies' should be conducted to ascertain the betterment values after improvements. Standard procedures for these should be evolved. Research on the use of local materials for different types of road surfacing must be undertaken. As a first step in tackling traffic and road safety problems, the Central Road Research Institute, Delhi, has now undertaken studies on the "Behaviour of Road Users" and "Fixing the time cycles for traffic light signals at road intersections."

Generally, there is an utter lack of road sense amongst all road-users, compared to the orderly behaviour in other countries. In urban areas, special studies must be carried out to find out the characteristics of road users and how far they are responsible for traffic hold-ups and accidents, and how far insufficient road widths and parking facilities and improper signalisation contribute to the increasing hazards on the roads.

4.3. Strict Enforcement

Due consideration must be given to pedestrians and cyclists who contribute most to road accidents. Pedestrians must be confined to side walks and must be allowed to cross only at crossings controlled by policemen. Guard rails should be fixed at edges of foot-paths at busy places to prevent roaming on the roads. Separate cycle tracks must be provided for cyclists. Traffic rules being more honoured in the breach than the observance must be checked by enforcing the traffic laws strictly. Violators should be prosecuted or fined as done in cities like Paris.

4.4. Building Safety into the Roads

More parking places, construction of public garages, adequate street lighting, proper control of traffic by road signs and light signals, and proper centre line marking along the carriageway should be provided. Construction of rotaries at important road intersections might serve the present needs, but with increase in traffic these might not be so efficient and effective later on. Hence, widening of roads at busy intersections and installation of automatic light signals to facilitate control will have to be thought of well in advance. Co-ordination of the work of the town planner and the road engineer is essential for achieving a well planned and designed road system in the urban areas. The town planners should be acquainted with the principles underlying modern road lay out to suit the demands of traffic.

4.5. Signs

The Motor Vehicles Act of 1939 has recommended uniform road signs and traffic signals all over India. In many cities these signs and signals are not located properly and are not maintained properly for giving the best service to road users. It is hoped that the system of signs prepared by the United Nations would be introduced throughout this country.

4.6. Vehicle Inspection

Poor standards of automobile maintenance lead to many avoidable accidents caused by mechanical defects. It is, therefore, imperative that a thorough checking of all vehicles by traffic authorities is done at regular intervals. Though some control is being exercised at present, it is not enough and rigorous enforcement is necessary.

4.7. Standard Forms for Obtaining Data on Traffic

There is an urgent need to adopt a uniform standard for obtaining and recording detailed information on road traffic, so that the data could serve a useful purpose in the proper design of the road and planning improved traffic control and enforcement measures.

4.8. Education

Widespread and well organized propaganda by means of lectures, films, radio talks, organization of safety weeks, should be continued persistently if any reasonable measure of success is to be achieved.

Co-ordination of efforts in all these matters by Government bodies like police, Education Departments, Roads Wing of the Ministry of Transport, Public Works Departments and Municipal Corporations, Research Organizations, like the Central Road Research Institute Delhi, and non-official organizations like Automobile and Road Safety Associations, Rotary Clubs and Courtesy Squads, etc., is essential.

The existing road traffic laws and regulations in various areas have to be carefully studied and amended or modified in the light of present day traffic conditions and future trends.

4.9. Commission of Road Traffic and Safety

The constitution of a 'Statutory Commission on Road Traffic and Safety' by the Government is necessary in view of the increasing complexities of traffic problems. This Commission can go into this question on a national level in detail and recommend necessary ways and means to control, regulate and improve road traffic and safety.

4.10. Traffic Engineering Unit

In all cities, a 'Traffic Engineering Unit' should be established for improving engineering and road safety facilities as an experimental measure and these could later on be expanded to full fledged departments depending upon the measure of success achieved. Initially these units may be attached to Public Works or Municipal Engineering Departments. A beginning in this direction has to be made and the sooner it is done the better for road traffic and safety in India.

ACKNOWLEDGMENT

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BIBLIOGRAPHY

1. 'Highway Engineering' — Laurence I. Hewes and Clarkson H. Oglisby.
2. 'Why we have Automobile Accidents'—Harry R. DeSilva.
3. 'Traffic Accidents and Congestion'—Maxwell Halsey.
4. 'Traffic Control and Road Accident Prevention'—Capt. Athelstan Popkess.
5. 'Road Traffic and its control'—Alker Tripp.
6. 'Highway and Road-Traffic Law' —R. P. Mahaffy.
7. 'Uses of Traffic Accident Records'—The Eno Foundation for Highway Traffic Control.
8. 'Basic Road Statistics of India,' —Ministry of Transport, Roads Organisation, Government of India.
9. 'Traffic Surveys under Indian Conditions' — C. S Anantapadmanabhan, Ministry of Transport, Roads Wing, Government of India.
10. 'Traffic Engineering'—May 1953, December 1954.
11. 'Public Safety—April 1954, October 1954.
12. 'Traffic Problems and Roads Safety'—R. K. N. Iyengar—Indian Builder, February, 1953.
13. 'Municipal Gazette—Transport and Roads Number'—Madras, December 1952.
14. 'The All India Motorist'—Delhi.
15. 'Road Safety in India'—1953-54.
16. 'An Analysis of Delhi Road Traffic Census,—R. L. Sondhi, Paper No. 14, Proceedings of the Second Meeting of the Indian Roads Congress, Bangalore.
17. 'A Small Scale Traffic Survey in New Delhi'—C. S. Anantapadmanabhan, Roads Wing, Ministry of Transport, Government of India, New Delhi.
18. 'Transport-Communications Monthly Review, July 1954,—No. 87, Indian Roads Congress, New Delhi.

PLATE I

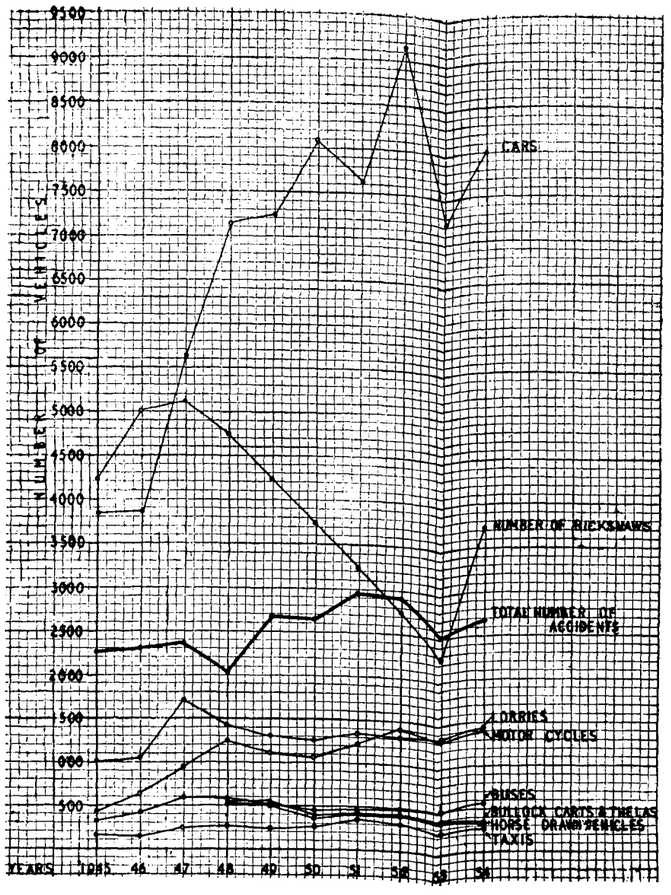

Fig. 3. Number of vehicles and accidents in Madras.

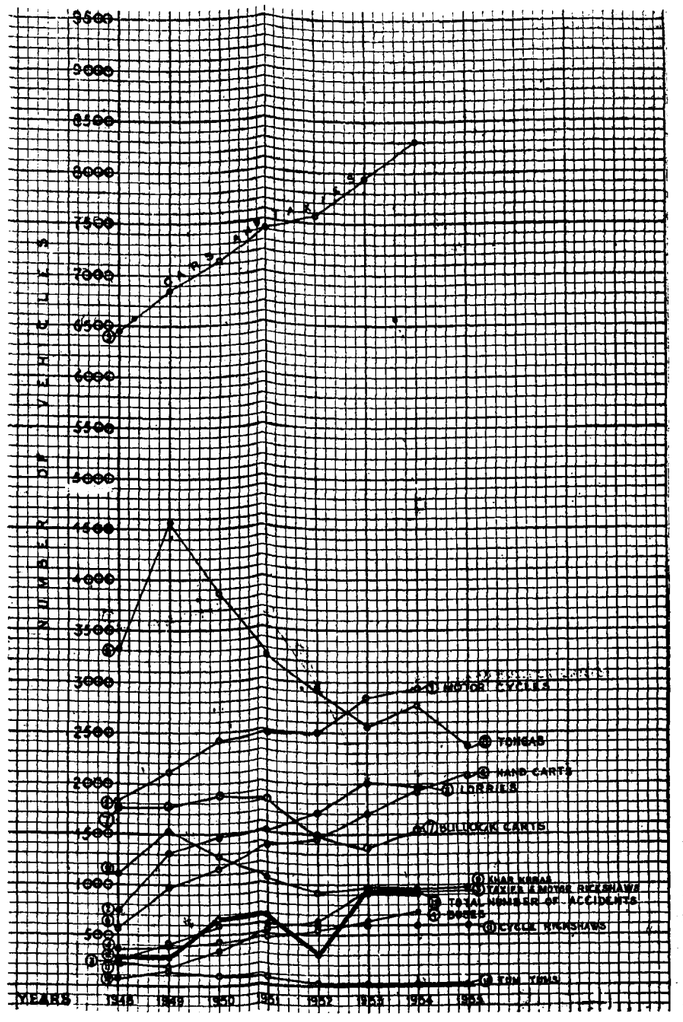

Fig. 4. Number of vehicles and accidents in Delhi.

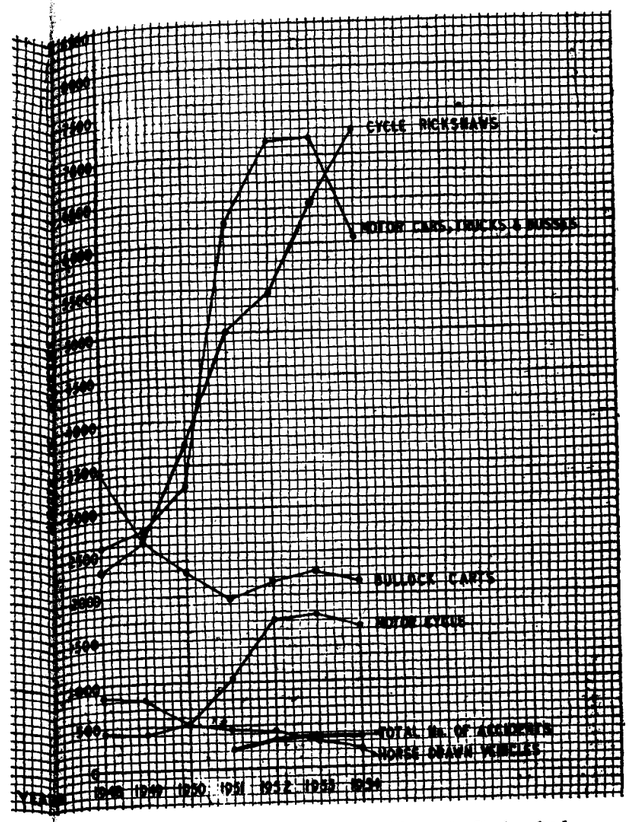

Fig. 5. Number of vehicles and accidents in Hyderabad.

Paper No. 188

"LIGHT SUSPENSION BRIDGES IN HIMACHAL PRADESH"

By

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AND

T. S. RUPAL, B.Sc., C.E.

CONTENTS

SYNOPSIS

A survey of the existing suspension bridges in Himachal Pradesh is nade and standards for loading and width for light suspension bridges are uggested.

A worked out example for design of a 200-ft light suspension bridge is ncluded.

1. GENERAL DESCRIPTION OF THE COUNTRY

1.1. The State of Himachal Pradesh is situated between North Latitude 30°-30′ and 33°-10′ and East Longitude 75°-55′ and 79°-50′. The area of the State is 10,600 sq. miles and its population about 10 lakhs. The State is divided into the administrative districts of Chamba, Mandi, Mahasu, and Sirmur. Plate I is a map of the State showing important roads, rivers, administrative divisions, location of some of the suspension bridges, and other details.

1.2. Being situated on the foothills of the mighty Himalayan range, the country is mountainous and partly covered with dense forests and vegetation. The altitudes range from 1,500 to 16,000 ft above the mean sea level. The annual rainfall varies from 30 to 130 in. most of which occurs during June to September. Portions of the country above 7,000 ft altitude generally get heavy snowfalls during the months of December to March.

1.3. The country is crossed by several big rivers such as Chandra Bhaga, Ravi, Beas, Sutlej and Giri, a tributary to the Jumna, in the early stages of their course. So, provision of an adequate system of road communications in the State is linked up with the construction of many bridges both over the big rivers and the smaller streams. Moreover, many villages are situated along the river valleys and the important towns like Chamba, Mandi, Bilaspur on the banks of the big rivers. Consequently, crossings of the rivers or their tributaries necessitate bridges of various spans in the road construction programme of the State.

1.4. The course of the rivers or streams being steep, the current is very swift and hence rocky sections of narrow gorges have to be selected as suitable sites for single-span bridges. The river beds in most cases consist of big boulders and shingle, which come rolling down from the hill tops. The big rivers like the Chandra Bhaga, Ravi, Beas and Sutlej, and some of the bigger streams are fed both by the monsoon rains and the snow melt in the higher regions and are perennial, while the smaller streams are dry and fordable during greater part of the year and become impassable only during rains.

1.5. The main agricultural wealth of the State consists of potatoes and fruits. The former is the chief cash crop and the State is the source of potatoes, especially seed potatoes, for the plains of India. The apple is the important fruit crop of the State. In addition, Himachal Pradesh forests contain the largest quantities of coniferous timber in northern India. They are the

main source of revenue of the State. For lack of adequate road communications, large quantities of timber are at present floated down the rivers to the plains with consequent losses in transit. Further, the mineral wealth of the area remains unexplored for want of proper road communications.

2. SURVEY OF EXISTING BRIDGING CONDITIONS

2.1. As most of the roads in the State were meant only for mule or pedestrian traffic and were not intended to cater for motor vehicles, crossings over big rivers or smaller streams existed in the form of one of the following expedients :

(a) Dry stone scupper which consists of a dry stone embankment with a suitable outlet for the passage of water across small streams. In times of heavy floods it serves as a causeway.

(b) Simple timber bridges which consist usually of three longitudinal wooden beams or logs with cross planking and wooden railing fixed to them for streams up to 40 ft wide.

(c) Wooden cantilever bridges or light steel girder bridges with wooden decking for bigger streams up to about 60 ft width.

(d) For spans of about 100 ft and above, light suspension bridges were constructed over main established routes while ropeway bridges, Plate II, and simple pulley-rope devices were used over subsidiary routes or for local crossings of rivers near villages.

2.2. While these temporary devices served their purpose very well on mule roads, permanent structures have to be constructed on motor road alignments which will replace the old mule roads. Difficulties of transporting materials and equipment necessary for deep foundations in boulder beds might militate against an extensive use of modern methods of bridge construction, particularly in reinforced cement concrete, in the upper hilly regions. From past experience it is seen that the suspension type bridges have proved quite successful in this region, and it is recognised that the design of existing bridges has to be modified to suit present day requirements of highway loading and other highway standards as applicable to traffic conditions in the State. In fact, some of the bridges have already been reconditioned or strengthened and are now safe for the passage of motor lorries.

2.3. The many existing suspension bridges over rivers in the lower Himalayan region were built at various times between 1890 and 1930. They are mostly between 100 to 200 ft in span and some have spans even longer than 200 feet. Their width is mostly 8 ft and below. A statement containing particulars of some of these bridges situated in Himachal Pradesh is given in Appendix 1, Photos 1 to 7.

2.4. The suspension bridges referred to above are mostly light suspension bridges, chiefly meant for pedestrian and mule traffic. The justification for their existence lies in the torrential nature of the rivers with deep channels in the mountainous region and high velocity of flow not permitting intermediate temporary or permanent supports. The light nature of hill traffic at the time of their construction and the difficulty of transporting materials other than those locally available were other reasons which favoured the adoption of light structures. A striking feature of these bridges is that they are invariably sited ideally at places where the course of the river runs through a gorge and is straight and the banks are very stable. It is not unusual to find in many cases the towers resting directly on solid rock and in some cases the cliffs themselves serving as towers for fixing the cables.

3. DESIGN FEATURES OF EXISTING SUSPENSION BRIDGES

3.1. As most of the bridges described in Appendix 1 have successfully stood the test of time to this date, it would be well worth while to consider some of the salient features of their design[1].

(a) **Loads:** A dead load of 50 lb per sq. ft. and a live load of 100 lb per sq. ft. were taken as a fair allowance for an average bridge in the upper part of the Sutlej Valley.

(b) **Types:** Suspension bridges were divided into the following two main classes:

(i) Unstiffened, and

(ii) Stiffened.

In type (i), a moving load was transferred direct to the cables by each suspender in turn. In type (ii), a moving load was transferred to the cables through the medium of trusses.

(c) **Towers**: The backstays were usually arranged so as to cause the resultant pressure on the towers to be vertical, but if

Photo 2. Dehar suspension bridge.

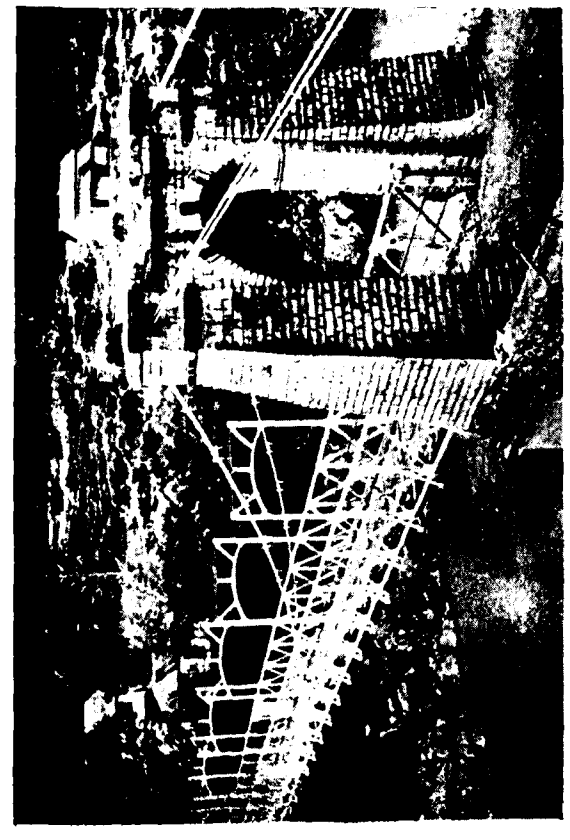


Photo 1. Bridge over Sutlej River at Dehar on Simla-Mandi Road.

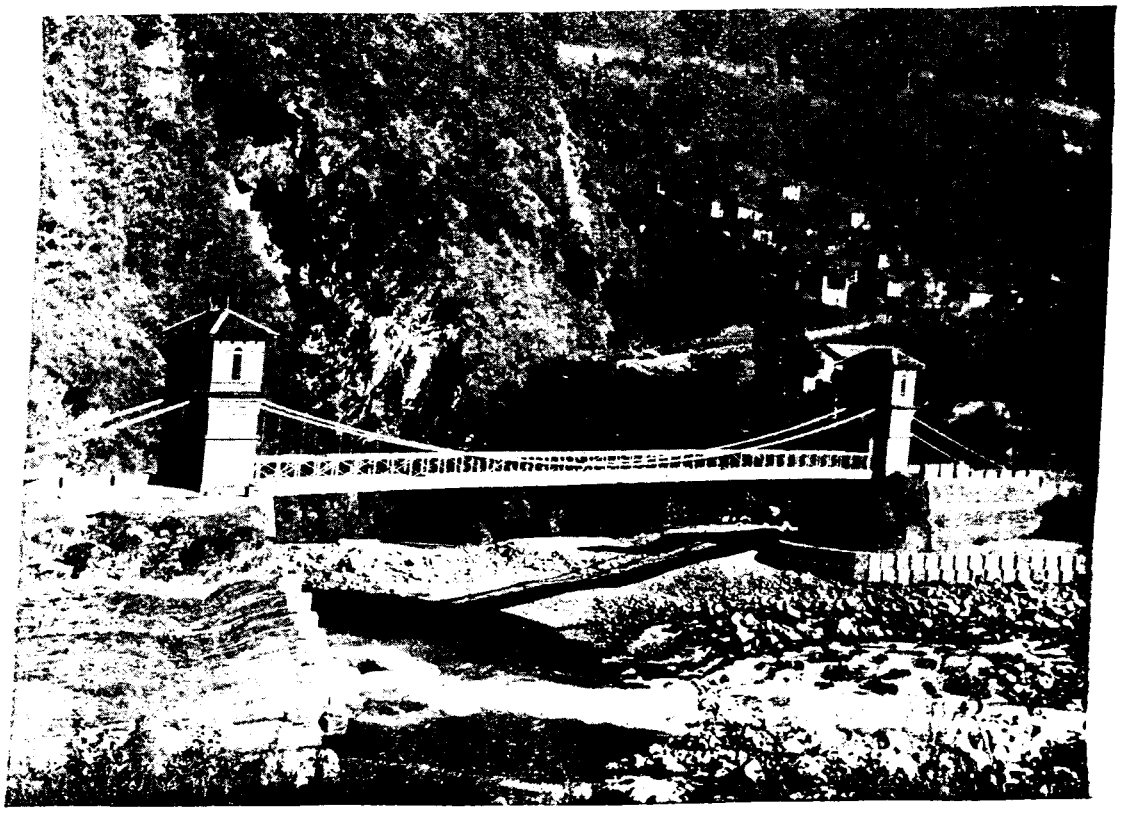


Photo 3. **Sitla suspension bridge at Chamba.**

Photo 4. **Suspension bridge over the Ravi on Chamba-Bhermatu Road at Rakh.**

Photo 6. Pully ropeway bridge at Chini.

Photo 7. Pully ropeway bridge at Chini.

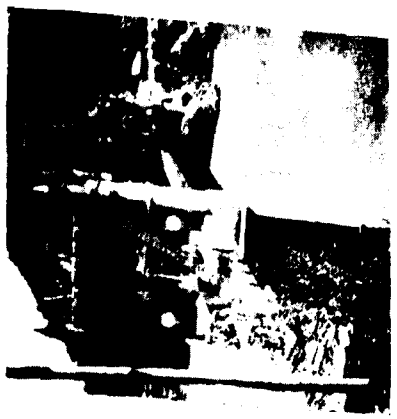


Photo 5. Victoria bridge over the Beas at Mandi.

this was not feasible, the towers were designed to withstand a resultant pressure at an inclination to the vertical.

(d) **Saddles:** It was generally desired to design the saddle so that the resultant pressure of the cables on the towers should be vertical. To obtain this effect, two conditions had to be fulfilled, viz.:

(i) the backstay and the tangent to the curve of the cable to make equal angles with the horizontal;

(ii) the tension on both sides of the saddle to be equal.

Three types of saddles were generally employed, viz.,

(i) C. I. block bolted to the tower — There was no provision to eliminate friction or to ensure equal tension through the rope.

(ii) C. I. saddle and rollers — This provided for the elimination of friction but was unsuitable for use when the inclination of the rope to the horizontal on either side was not equal.

(iii) C. I. rocker and bed plate — This was an improved type suitable to all conditions. The rocker would move so as to equalise tension and the resultant force would then be vertical, if the angles of the cable and the backstay to the horizontal were equal. If this was not the case the resultant force would pass through the axle pin.

(e) **Camber**: The real function of the camber was to compensate for deflection of the roadway under live load so that a concentrated load moving over the bridge actually moved in a horizontal path instead of always climbing a slope due to deflection. On this hypothesis, the amount of camber required at any point was a calculable quantity, being equal to the corresponding deflection due to maximum load.

(f) **Wind Ties:** The drawback of the unstiffened type of bridge was its flexibility which admitted of movements in the roadway. These movements were of two kinds:

(i) deformation due to concentrated or partial live load causing a vertical movement of the roadway resulting in undulations.

(ii) lateral movement due to wind pressure causing swaying. Wind ties were necessary to counteract this effect.

(g) **Cradling:** By cradling the cables to an inclination of 0° to the vertical, the lateral oscillation due to wind pressure ould be reduced to about one-half at the cost of an increase of ension in the suspenders and main cables of only 3.5 per cent. t did not, however, appear advisable to increase the angle of nclination further as the results did not justify a corresponding ncrease in the strength of the cables.

(h) **Stiffening Truss:** Unlike an ordinary truss, the function of this truss was to distribute loads uniformly to the suspenders and so to the cables and not to transfer loads to the supports at its ends. It was assumed that the cable retained its parabolic form and carried the entire dead load. The truss had to be designed for live load only.

In actual practice on bridges of about 150 ft span, the depth of the truss was usually taken as 5 ft and the transoms were placed 5 ft apart, thus giving a square panel truss. Timber trusses were generally adopted to serve both as stiffening girders and hand rails. The purpose of stiffening was, however, not fully fulfilled by this means as timber deteriorates under exposure to weather and requires frequent renewals. In relatively light structures timber trusses can be provided cheap and made effective when properly jointed and provided with metal gusset plates and bolts.

The maximum bending moment for a self-supporting simple truss was $WL^2/8$ while for the suspended truss it was $WL^2/54$. This was according to the common theory of the suspension truss as first evolved by Rankine. For a heavy dead load and a light live load it was not far from correct; for a light dead load and a heavy live load the stresses would be different from the above.

Regarding horizontal stiffening against wind pressure, not infrequently the lower booms of the vertical trusses served also as booms to the horizontal truss, and in this case they are required to be designed with sufficient strength for both the functions.

4. RECENT ADVANCES IN SUSPENSION BRIDGE DESIGN

4.1. Suspension bridges are now used in western countries not only for relatively narrow structures suitable for trails, forest development, or other light traffic roads but also in the construction of some of the largest bridges each of which constitutes a special problem in itself.

4.2. The design of suspension bridges, though highly involved, is flexible, depending, in the main, upon:

(a) the dead load of the structure;

(b) the intensity and position of the live load;

(c) the area and elastic properties of the cable system;

(d) the moment of inertia of the stiffening truss.

The design is influenced still further by temperature changes, by the span arrangement, and by the sag ratio chosen to fit a particular site.

4.3. Suspension bridges can be classified and grouped in a number of ways. The principal classifications are:

(a) By type of the suspension system, such as
  (i) forged-link chains,
  (ii) eye-bar chains,
  (iii) wire cables, and
  (iv) other miscellaneous arrangements.

(b) By the method of stiffening the suspension system, such as
  (i) unstiffened*,
  (ii) integrally stiffened, and
  (iii) deck stiffened.

(c) By the loading of the suspension system, such as
  (i) structures with loaded backstays, and
  (ii) with unloaded backstays.

(d) By the anchorage of the suspension system, such as
  (i) externally anchored, and
  (ii) self-anchored**.

* Used for (1) light construction, such as foot-bridges, forest trail structures, etc., where the moving load is negligible and deflection requirements are not controlling; (2) very long spans where the ratio of dead to moving load intensity is so great as to render stiffening unnecessary.

** By the employment of horizontal struts or girders extending from end to end of the structure, generally at roadway deck level, designed to carry the horizontal component of the cable stress, thus relieving the end piers of all forces vertical ones.

4.4. The three methods commonly employed for analysis of suspension bridges are :

(a) the Elastic Theory ; (b) the 'Melan' or Deflection Theory ; and (c) the Fourier Series method.

The Elastic Theory disregards the effects of deflection while the Melan Theory takes this into account. Further, while the assumption that the cable remains parabolic under all live load conditions is approximately true for a loading occupying the entire span, there may be a considerable distortion from the parabolic form for long spans and heavy concentrated loads. The Fourier Series method takes this secondary distortion into consideration and is, therefore, the most precise method of the three.

4.5. In practice, however, the elastic or approximate theory is generally used in the first instance with a subsequently applied correction to reduce all shears and moments to be substantially identical with those derived by the deflection method. The deviation from precision is thus exceedingly small.

4.6. Two-hinged truss type suspension bridges with unloaded or straight backstays are generally suitable for the conditions prevailing in the hills of the lower Himalayan region. The formulae for this type derived by the application of the Elastic Theory are based upon the following assumptions :

(a) the cable is perfectly flexible ;

(b) the entire dead load is carried by the cable without stressing the stiffening system. The trusses are stressed by live load and by changes of temperature ;

(c) the dead load of the floor, trusses, and cables is uniform per linear unit, measured horizontally, so that the dead load curve of the cable is a parabola ;

(d) under application of live load, the cable retains parabolic form ; and

(e) the stiffening trusses or girders have a constant moment of inertia.

5. BRIDGING POLICY IN THE STATE

5.1. Two important points deserve consideration before examining the requirements of light suspension bridge structures for the various classes of roads in the State. These are :

(a) width of roadway, and

(b) live load for which the bridge is to be designed.

5.2. Width

The existing suspension bridges enumerated in Appendix 1 are mostly 8 ft and below in width. The roads over which they are situated were, no doubt, meant only for mule and pedestrian traffic in the past but with their improvement or realignment to new standards, work on which is now in hand, it is expected that full value of the improved roads will be derived only when loaded trucks up to 10-ton capacity, Fig. 1, are able to pass over them. The minimum width of roadway over the bridge required in that case will be not less than 9 or 10 ft for one traffic lane.

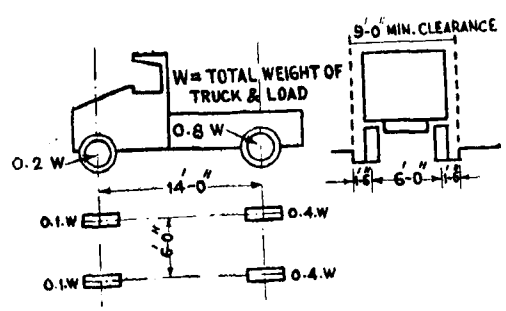


Fig 1.

5.3. Live Load

The light suspension bridges under consideration cannot probably be classed as permanent structures. As such, and on account of the fact that they will not be called upon to carry loads heavier than a 10-ton truck in a foreseeable period of time, it will be sufficient if these structures are designed for Class B loading of the Indian Roads Congress. Taking a load intensity of 100 lb per sq. ft. and assuming that the width of roadway over the bridge is 10 ft. the equivalent uniformly distributed load is 0.56 tons per running foot including an impact allowance of 25 per cent. For spans of 200 ft and above, this would be higher than Class 30 loading[5]. Similarly, if we take a load intensity of 85 lb per sq. ft., it would be seen that this would correspond exactly to Class 30 loading for the conditions mentioned above.

Further, the load intensity of 100 lb per sq. ft. with the same road width and impact allowance as assumed previously would roughly correspond to Class 24 loading for a span of 100 feet. It would, therefore, be seen that for shorter spans the assumed live load intensity for design purposes would have to be increased if a particular class of loading is to be adhered to.

5.4. Based on the above mentioned considerations, suggested standards in respect of width and design loading for light suspension bridges for various classes of roads in the State are given in Table 1.

TABLE 1

Suggested Loading and Width Standards

Class of road	Clear width in ft between		Live Load
	Wheel-guards	Railings	
(a) State Highway	10	12	I.R.C. Class A train of loads or corresponding equivalent uniformly distributed load.
(b) (i) District Road, Major.	10	12	I.R.C. Class A train of loads or corresponding equivalent uniformly distributed load (except in cases where permanent structures would be expensive).
(ii) District Road, Minor.	10	12	I.R.C. Class B train of loads or corresponding equivalent uniformly distributed load.
(c) Jeepable tracks on motor road alignments.	6	8	85 lb per sq. ft.
(d) Tracks providing access to a motorable road or to pasture grounds (A jeep may occasionally be expected to pass over such roads).	5.5	6.5	85 lb per sq. ft.

5.5. Indian Roads Congress Class A loading corresponds to Class 40 loading for a span of 80 ft. The closest approximation to Class 40 loading for spans of 200 ft and above for a 10 ft width of roadway would be 120 lb per sq. ft. Under conditions prevailing at present and taking into account the foreseeable future development it would not appear justifiable to design light suspension bridges for a live load intensity greater than 120 lb per sq. ft.

5.6. Suspension bridges in the hills have invariably to be sited on a straight reach of the river at narrow and well defined sections where there is least possibility of change occurring in the course of the stream on account of local obstructions and where hard rock on either bank is available for foundation of abutments or towers. In addition, reasonable proximity to a direct alignment of the road, i.e., avoidance of long detours is also to be aimed at. Sometimes it happens that a rocky site is situated on a bend in the course of the river and this happens for the very reason that there is solid rock which the river cannot pierce through. The suitability of such rocky sites has also to be considered.

Most of the existing bridges are situated at suitable sites. They were built just after a vertical fall in the course of the stream so that the force of the water current was dissipated in the fall. In selecting suitable sites for new bridges this point has to be carefully assessed. In some cases, protection to the banks is necessary and in one instance protective works of cement concrete blocks with embedded chain along either bank of the upstream side of the river have eliminated the danger from scour to the abutments.

5.7. A strict application either of the catchment area method or the area-velocity method for the determination of maximum discharge is not possible for hill streams on account of the rugged nature of their courses and the surrounding country. When narrow rocky sections or gorges are selected for siting bridges, the linear waterway for single-span bridges is automatically fixed and what is required to be determined with accuracy is the highest flood level. In case of big rivers, the discharge can be determined with a fair amount of accuracy from the cross-sectional area at the proposed site and the average slope of the river bed. As, however, some indeterminate factors like cloud bursts—which are not rare in the hilly areas—temporary obstructions of the streams on account of landslides and uprooted trees, or the melting of the snows in the higher regions are involved, an increase of the minimum vertical clearances between the H.F.L. and the lowest point of the deck structure, prescribed under

Clause 105 of the Indian Roads Congress revised Bridge Code*, is called for in order to prevent overtopping of the bridge during heavy floods. Instances of overtopping are not wanting in these regions to justify the provision of an increassed vertical clearance depending upon the conditions at site.

5.8. A worked out example of the design of a light suspension bridge of two-hinged type with straight backstays using Steinman's method which will serve to illustrate the points mentioned above is given in Appendix 2. Detailed drawings are given in Plates III and IV. An abstract of quantities and cost is given in Appendix 3.

6. SOME POINTS REGARDING CONSTRUCTIONAL FEATURES

6.1. Economic Proportions

The length of side spans of a suspension bridge depends upon the shore conditions at site. Generally, the ratio of side spans to main span is about 1/4th for straight backstays. As the approaches on hill roads are generally at right angles to the bridge, the design must ensure that the cables from the top of the piers to the anchorages allow sufficient headroom for the traffic.

For light highway bridges, the sag-span ratio may be taken as 1/10 to 1/12. The lesser the dip the stiffer is the bridge, but the greater is the stress in the cables. To allow for stretch in the cables, the process of tightening being more difficult than slackening, the dip should be adjusted originally to about 4/5 to 4/10 of the final requirement according to the local conditions.

The depth of the stiffening girder depends upon the required degree of rigidity. For ordinary highway bridges the depth may not be less than 1/40 to 1/50th of the span. Generally, a shallower truss is preferred for appearance as well as for economy. The distance between the stiffening trusses depends upon the road width to be provided but for sufficient lateral stiffness it should preferably not be less than 1/30th of the span.

6.2. Materials Used

The stiffening trusses are generally built of structural steel. With changes in temperature and humidity timber developes cracks and the joints become loose. Therefore use of timber for stiffening trusses defeat the very purpose which they are meant to serve. Timber trusses may, however, serve their purpose for structures meant exclusively for mule and pedestrian traffic.

* Extract given on page 378.

The cables are made of galvanised steel wire ropes. The approximate weight of the rope in pounds per linear foot is $1.68 \times (\text{diameter})^2$ and the ultimate strength of galvanised steel suspension bridge ropes in pounds is given approximately by $80{,}000 \times (\text{diameter})^2$, but values prescribed by the manufacturers should preferably be adopted. To allow for changes in length of the cables made of wire ropes, screw and nut arrangement should generally be provided.

Eyebars or flats are also used for cables. While wire cables are self-supporting during erection, lighter in weight and have a high reserve capacity for loads heavier than the design loads, eyebars or flats give a more rigid structure.

The suspenders are either of galvanised steel ropes or structural steel rods. In the latter case, bending stresses due to lateral or longitudinal swaying of the bridge are avoided by inserting pin connections or links.

The towers are built either of structural steel or stone masonry or cement concrete.

All castings, such as saddles, cable bands, anchor shoes, knuckles, etc., are made of cast steel. Suspender sockets are made by drop-forging and machining.

6.3. Vertical and Lateral Stiffening

Vertical stiffening is sometimes secured by introducing diagonal stays between the tower and the roadway, although these make the stress action uncertain and introduce unbalanced stresses in the towers.

The wind bracing provided in the plane of the bottom chords is often supplemented by land-ties or wind anchors, i.e., ropes connecting points on the roadway to the piers or to points on shore.

Cradling of the cables, i.e., building the cables and suspenders in inclined planes, also secures lateral stiffness, though at some sacrifice of uniform stress in the cables. If the cables are cradled, the reactions at the saddles on the tower will be inclined and to overcome this effect the backstays have to be made divergent.

6.4. Towers

Towers are built either of masonry or steel. In the former case, they are built as two columns from a common base beneath

the roadway and connected together at the top in the form of an arch. The tower legs are designed as columns to take the vertical reaction of the cables and also as cantilevers to resist the unbalanced horizontal forces, if any.

Saddles provided on the towers to take the cable are either bolted to the top of the tower or provided with rollers. In the former case, any unbalanced horizontal force must be allowed for in the design of the tower. In the latter case, the eccentricity of the vertical reaction has also to be provided for.

6.5. Anchorages

These are very important parts of the structures as the safety of the whole suspension bridge depends upon them. In places where rock is not available for anchoring the cables direct into it, massive masonry construction is required to resist the cable pull. Stability against sliding can be increased, if required, by sloping or stepping the base, thereby increasing the sliding resistance. In general, the resultant of all the external forces must not cause uplift at the heel of the anchorage block and the inclination of the resultant from the normal must not exceed the angle of friction.

The anchor chains pass through the masonry and are fastened at their ends to anchor plates or girders distributing the pressure on a sufficient mass of masonry.

The anchorage devices should be safe and be available for periodical inspections. Alternatively, they can be embedded in concrete in order to be free from the effects of air and moisture.

6.6. Erection

One of the great advantages of light suspension bridges under conditions prevailing in Himachal Pradesh is the facility for erection. The normal order of erection is: towers and anchorages, cables, suspenders, stiffening trusses, and floor system.

7. CONCLUSIONS

7.1. Taking into consideration various factors, such as availablity of suitable sites, difficulty in transport of materials and equipment, lack of skilled labour, ease and speed of erection, cheapness in cost of construction, etc., conditions in the hilly areas of the region comprising the State of Himachal Pradesh are

favourable for the construction of light suspension bridges for spans above 100 ft. Many existing suspension bridges which are now over 50 years old have successfully stood the test of time and proved very useful for mule and pedestrian traffic which they were meant to carry.

The chief drawbacks of the existing structures are: (i) cable strength not sufficient for taking heavy loads, (ii) insufficient width of roadway for motor vehicles, and (iii) lack of rigidity in the structure. An attempt has been made in this Paper to see how these difficulties can be overcome by providing sufficient cable strength to take the anticipated load, keeping the roadway over the bridge not less than that required for a minimum traffic lane width in the case of bridges meant for vehicular traffic, and providing steel girders for stiffening purposes as timber is unsuited for this purpose.

7.2. Light suspension bridges of the type envisaged in this Paper cannot be classed as permanent structures, neither can they be called temporary in the ordinary sense in which timber structures are classified. They will remain in service till construction of permanent bridges in steel or concrete becomes feasible in the hilly regions difficult of access and whose development may not justify provision of costly bridge structures just at present.

7.3. As traffic on the motor roads under construction in the area increases and the region is developed and industrialised, the light suspension bridges could be replaced by more permanent structures by which time they will have amply justified their existence.

ACKNOWLEDGMENT

The Authors acknowledge their indebtedness to the Chief Engineer, Himachal Pradesh, for his suggestions and help, and the Punjab P.W.D. for permitting use of some of the information available with them in the preparation of the Paper.

REFERENCES

1. *Proceedings of the Punjab Engineering Congress*, Volume X (1922).
2. Analysis of Partly Stiffened Suspension Bridges by Halero Johnston, *Proceedings of the Punjab Engineering Congress*, Volume XIII (1925).

3. A Practical Treatise on Suspension Bridges, D. B. Steinmann, Joh Wiley and Sons, Inc.

4. Simple Theory of Suspension Bridges by Professor A. G. Pingsley *Journal of the Institution of Structural Engineers*, March, 1953.

5. Bridge Code - Section II, Loads and Stresses, *Journal of the India Roads Congress*, Volume X-3, January, 1946.

6. Military Engineers Services Handbook, Volume III, Part 1 (1941).

Extract from Clause 105 of the Indian Roads Congress Revised Bridge Code

* * *

(a) For openings of high level bridges, which are approximately rectangular, or with a very flat curve of the soffit of superstructure, as for instance in the case of beam, frame, or bow-string superstructures, continuous girders or open spandrel arches with suspended decking, the *minimum* clearance shall be in accordance with the following table :

Discharge	Vertical clearance
Below 10 cusecs	6 in.
10–100 ,,	1 feet 6 in.
100–1000 ,,	2 feet
1000–10,000 cusecs	3 feet
10,000–100,000 cusecs	4 feet
over 1,00,000 ,,	5 feet

The minimum clearance shall be measured from the lowest point of the deck structure inclusive of main girders in the central half of the clear opening.

* * *

Appendix 1

PARTICULARS OF LIGHT SUSPENSION BRIDGES IN HIMACHAL PRADESH

Serial No.	Name of bridge and situation.	Year of construction.	Brief description.	Description of railings or stiffening trusses.	Height of formation of road above the bed of nullah.	Brief particulars of foundations.	Number & length of spans.	Clear road width.	Total length of bridge.	Particulars of cost where available.	Cost per foot run.	Load capacity of bridge.	H.F.L. & particulars of protective works, if any.	Remarks.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Sitla suspension Bridge over the Ravi at Chamba on Chamba-Bhaniket Road, Photo 3.	—	Cables of M.S. flats, wooden decking, anchorages below ground level on both sides.	Wooden stiffening girders serve as railings.	44′–0″ from low water level.	Both abutments and towers are of stone masonry and rest on hard rock.	One span 220′–0″ clear.	7′–0″	244′–0″	—	—	Safe for 5-ton lorries.	—	Protective works of cement concrete blocks with embedded chain on the upstream side protect the abutments from scour.
2.	Victoria Bridge over the Beas at Mandi on Amritsar-Pathankot-Kulu Road, Photo 5.	1887	Six cables of G.I. wires 2 in. dia. on each side, 1 in. dia. G.I. wire suspenders, wooden decking. Left anchorage: stone masonry block 50′ × 22′ × 18″ size; right anchorage girders fixed direct into hard rock.	$3\frac{1}{2}″ \times 3\frac{1}{2}″ \times \frac{1}{2}″$ angle iron booms and $4″ \times \frac{3}{8}″$ flat iron cross braces, 4′ high from the decking.	28′–0″ at the abutments.	Both the abutments and towers are of stone masonry and rest on hard rock.	Main span 250′–0″ one simply supported shore span 20′–0″ length on Mandi side.	9′–0″ clear between wheel-guards and 11 ft between railings.	—	—	—	5-tons specified	—	—
3.	Bhojwani suspension Bridge over the Sutlej at Bilaspur on Simla-Mandi Road.	1889	Four cables $1\frac{1}{4}$ in. dia. on each side, wooden flooring, masonry towers resting directly on rock, and masonry anchorages for cables on both sides.	Wooden railings 3′–6″ high serve as stiffening girders.	—	The towers rest directly on rock.	Main span 280′–0″; simply supported shore span 50′–0″ on Bilaspur side.	9′–0″	330′–0″	Rs 28,571	Rs 86.9	Lorries can go over the bridge.	—	This bridge is situated in the Bhakra Dam reservoir area.
4.	Wangtu Bridge over the Sutlej on Hindustan Tibet Road.	1897–98	4 steel wire cables $1\frac{1}{4}$ in. dia. on each side, steel towers & wooden decking. Diagonal bracing and wind ties are provided.	Wooden stiffening girder.	40′–0″ above water level.	Left abutment is rock and the right abutment is founded on rock.	One span 141′–0″	6′–4″	141′–0″	—	—	—	—	The site of the bridge is a good one with rock on both sides & good approaches.
5.	Dehar Bridge over the Sutlej on Simla–Mandi Road at Dehar, Photos 1 & 2.	1909	Two cables of G.I. wire 2 in. dia. on each side, masonry towers resting on hard rock, wooden decking. Anchorage: left fixed in hard rock; right stone masonry block $\frac{1}{2}$-in. dia. G.I. suspenders.	Steel stiffening girders of angle iron posts and pipe railings 6 ft high.	65′–0″ from the river bed.	Both the abutments of chiselled stone masonry resting on hard rock.	214′–0″ clear.	7′–6″ between wheel-guards and 8′–0″ between railings.	230′–0″	Rs 29,716	129	3-ton lorries.	H.F.L. 94 ft above bed level.	This bridge is situated on the limit of submergence of Bhakra Dam reservoir area.

Appendix 1 (*Contd.*)

Serial No.	Name of bridge and situation.	Year of construction.	Brief description.	Description of railings or stiffening trusses.	Height of formation of road above the bed of nullah.	Brief particulars of foundations.	Number & length of spans.	Clear road width.	Total length of bridge.	Particulars of cost where available.	Cost per foot run.	Load capacity of bridge.	H.L.F. & particulars of protective works, if any.	Remarks.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6.	Luri Bridge over the Sutlej at Luri.	1900	Two steel wire cables 1 in. dia. on each side. Wooden flooring suspended by $\frac{1}{2}$ in. dia. M. S. Rods. Stone in lime mortar masonry towers, resting on rock. Cables anchored to masonry blocks 10′×6′×5′. Wind ties anchored to masonry blocks.	Wooden stiffening girders serve as railings.	35′-0″	One abutment is solid rock and the other is founded on rock.	One span 121′-0″	6′-3″	121′0″-	—	—	—	—	—
7.	Nogli khud Bridge on Luri-Rampur section of Hindustan-Tibet Road	1900	Steel wire cables and wooden decking. Right abutment is of dry stone masonry. Left abutment is rock. Cables are fixed directly into rock. Towers are of stone masonry in lime mortar.	Wooden railings.	20′-0″ above water level.	The right abutment is founded on firm ground.	One span 80′-0″	6′-3″	80′-0″	—	—	—	—	Right abutment of dry stone masonry was badly undermined in 1924 and a dry stone masonry apron has since been provided.
8.	Doubling bridge over the Sutlej on Hindustan-Tibet Road.	1912	Unstiffened wooden suspension bridge with steel cables, stone in lime mortar masonry abutments and towers, and wooden flooring.	—	About 75′-0″	Both abutments are founded on solid rock.	One span 165′-0″ distance between points of suspension is 174′-0″	3′-3″	165′-0″	Rs 29,354	Rs 177-14-0	120 lb per sq. ft.	—	—
9.	Suspension Bridge over the Sutlej at Tatapani on Simla-Nalderra Tatapani Road.	1895	Two G.I. wire cables on each side, steel towers wooden decking, 1 in. dia. suspenders and wind ties of 1 in. dia. rods are provided.	Wooden stiffening girders serve as railings.	70′-0″ above water level.	Abutments erected on hard rock.	One span 120′-0″ clear.	5′-3″	133′-0″	—	—	Safe for mules and light jeeps only.	—	—

DESIGN OF A LIGHT SUSPENSION BRIDGE

Worked out Example

(See Plates III & IV)

Take the case of a suspension bridge of the following particulars:

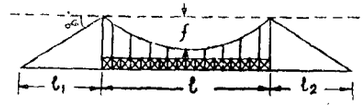


Fig. 1.

l = main span, centre to centre of towers (also the span of the stiffening truss).

= 200 ft

Side spans $l_1 = l_2 = \frac{l}{4}$ = 50.00 ft

f = cable sag in main span = $\frac{l}{10}$ = 20 ft $\left(n = \frac{f}{l} = \frac{1}{10}\right)$

Cable sag in side spans = 0 (straight backstays)

d = depth of stiffening truss = 6 ft

Width of roadway over the bridge = 10 ft within wheel guards and 12 ft between railings.

Live load assumed for design:
(a) For decking: 10-ton truck; Fig. 1, p. 371.
(b) For cables and trusses: 100 lb per sq. ft.

1. ROAD PLANKING

Dead Load

Planking 5 in. $\frac{5}{12} \times 36 = 15.0$ lb

1 in. premixed carpet $\frac{1}{12} \times 150 = 12.5$ lb

27.5 or 30 lb.

Assuming a 10 in. width of tyre, spacing of stringers as 3 ft centre to centre and a safe working stress for Deodar planking

under outdoor conditions as 1230 lb per sq. in. The thickness of planking works out 4.75 in.

Adopt 5 in. thick planks.

2. LONGITUDINAL STRINGERS

Span = 5 ft

Assume a 5 in. × 4½ in. × 20 lb R.S.J.

Dead Load

(a) Load of planking and carpet per ft run of the stringer

= 30 × 3 = 90 lb.

(b) Weight of Joist = 20 lb per foot run.

Total: 110 lb per foot run.

Dead load bending moment = $\frac{110 \times 5 \times 5 \times 12}{8}$ = 4125 in.—lb.

Live Load

Impact factor = $\frac{30}{45+5}$ = 0.6

But maximum allowed = 0.55

Therefore, wheel load with impact = 4 × 1.55 = 6.2 tons.

Maximum live load bending moment = $\frac{Wl}{4}$

[Fraction of live load on one stringer may be taken as $\frac{S}{4}$, where S = average spacing of stringers in ft.]

$\therefore$ Max. L.L. B.M. = $\frac{3}{4} \times \frac{6.2 \times 2240 \times 5 \times 12}{4}$ =

156,240 in.-lb.

Total bending moment = 160,365 in.-lb.

B.M. = $f \times z$

$z = \frac{160365}{8 \times 2240}$ = 8.95 in.³

Modulus of Section of 5″ × 4½″ × 20 lb R.S.J. = 10.01 in.³

Hence section assumed is safe.

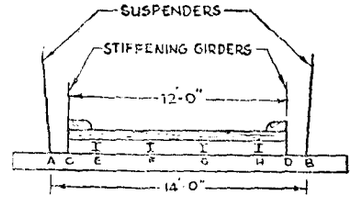


Fig. 2.

3. CROSS BEAMS

The load points are shown in Fig. 2.

A & B.....where the cross beams are suspended by means of suspenders.

C & D.....where the stiffening girders rest.

E, F, G & H.....where the stringers rest.

Dead Load

Dead load at points E, F, G, H :

(i) Planking and carpet = 30 × 3 × 5 = 450 lb

(ii) Stringer (R.S.J.) = 20 × 5 = 100 ,,

Total: 550 lb

Dead Load at points C & D :

Load per panel of stiffening girder is assumed as follows :

(i) Top boom 2 Angles 6″ × 6″ × 3/8″ @ 14.82 lb
= 2 × 5 × 14.82 = 148.2 lb

(ii) Bottom boom 2 Angles 6″ × 6″ × 1/2″ @ 19.55 lb
= 2 × 5 × 19.55 = 195.5 lb

(iii) Diagonals 2 Angles 2½″ × 2½″ × ¼″ @ 4.04 lb
= 2 × 2 × 7.8 × 4.04 = 126.0 lb

(iv) Verticals 2 Angles 2½″ × 2½″ × ¼″ @ 4.04 lb
= 2 × 6 × 4.04 = 48.5 lb

(v) Wind bracing 2 Angles 2½″ × 2½″ × ¼″ @ 4.04 lb
= 2 × 13 × 4.04 = 105.0 lb

Total: 623.2 lb

Say 650 lb

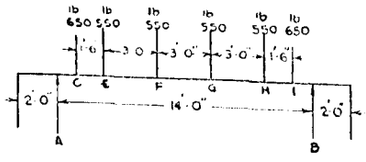


Fig. 3.

$R_A = R_B$ = 1750 lb, Fig. 3

Maximum B.M. = $1750 \times 7 - 650 \times 6 - 550\,(4.5 + 1.5)$

= 5050 ft-lb.

B.M. due to self weight of beam :

assuming 10″ × 5″ R.S.J. at 30 lb per foot run.

B.M. at centre $= \dfrac{30 \times 14 \times 14}{8} - 60$

= 675 ft-lb.

Total B. M. 5725 ft-lb = 68,700 in.-lb.

Live Load, Fig. 4

Maximum wheel load = 4.0 tons.

Impact factor $= \dfrac{30}{45 + 14} = 0.51$

Load with impact = $4 \times 1.51 = 6.04$ tons.

Wheel track for standard truck = 6 ft centres

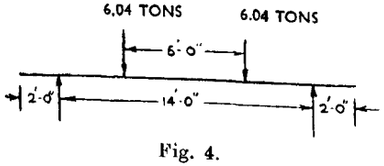


Fig. 4.

B. M. at centre = $6.04\,(7-3) \times 2240 \times 12 = 649{,}500$ in.-lb.

Total dead and live load B. M. = 718,200 in.-lb.

Modulus of section required $= \dfrac{718{,}200}{8 \times 2240} = 40.1$ in.^{3}

Provide 10″ × 6″ R. S. J. @ 40 lb with z = 40.96 in.^{3}

Actually 2 channels 10″ × 3″ = 43.80 have been used.

4. CABLE SECTIONS

Mean chord sections of the stiffening girder assumed as follows :

Top chord = 2 angles 6 in. × 6 in. × 3/8 in.

Area = $2 \times 4.36 = 8.72$ sq. in.

Bottom chord = 2 angles 6 in. × 6 in. × 1/2 in.

Area = $2 \times 5.75 = 11.5$ sq. in.

I = Mean moment of inertia of the stiffening truss in the main span

= $8.72\,(3.41)^2 + 11.5\,(2.59)^2$

= 178.5 in.^{2} ft^2 (for one truss)

Area of Cables, assuming there are 4 cables of 2 in. dia. on each side

A (cable section) = $4 \times \dfrac{\pi 2^2}{4} = 12.57$ sq. in.

Weight of galvanised steel wire rope per linear foot $= 1.68\,d^2$ lb

(*Note* : Actual values of cable area and weight prescribed by the manufacturers should be used).

Tan α = slope of cable in side span $= \dfrac{4f}{l} = 4n = \dfrac{4}{10} = 0.4$

Sec α = 1.077

Dead Load (per foot run of bridge)

(i)	Due to cables = $8 \times 1.68 \times 4$	= 54
(ii)	Suspenders 1 in. dia. 15 ft average length (assumed) $= \dfrac{2 \times 15 \times 2.67}{5}$	= 16
(iii)	Carpet 1 in. thick = $1/12 \times 10 \times 150$	= 125
(iv)	Planking = $5/12 \times 36 \times 12$	= 180
(v)	Wheel guards = $3/4 \times 1 \times 36 \times 2$	= 54
(vi)	Stringers = 4×20	= 80
(vii)	Stiffening girders etc. at 700 per panel	$= 2 \times 700 =$ 1400
(viii)	Cross beams = $18 \times 40 = \dfrac{720}{2120/5}$	= 424
		933
		Say 1000 lb.

Live Load

100 lb per sq. ft. U. D. L.

$= 100 \times 10 = 1000$ lb per ft. run.

Hence total load per foot run of bridge

$= 1000 + 1000 = 2{,}000$ lb.

w = dead load per set of cables = 500 lb per linear foot

p = Live load per set of cables = 500 lb per linear foot

t = assumed temperature variation say $\pm$ 60°F.

$E \psi t = 30 \times 10^6 \times 6.5 \times 10^{-6} \times 60$

$= 11{,}720$ lb per sq. in.

(i) H, the horizontal component of cable tension for dead load:

$$H = \frac{wl^2}{8f} = \frac{10}{8} \times 500 \times 200 = 125{,}000 \text{ lb}$$

(ii) For live load, N in the denominator of the formula for horizontal component of tension is given by the equation*

$$N = \frac{8}{5} + \frac{3I}{Af^2}\frac{E}{E_c}\left\{1 + \frac{8f^2}{l^2}\right\} + \frac{6EIl_1}{AE_c l f^2} \text{ Sec}^3 \alpha$$

[According to Steinman, $\frac{E_c}{E} = \frac{2}{3}$]

Substituting the values, we have:

$$N = \frac{8}{5} + \frac{3 \times 178.5}{12.57 \times 20 \times 20} \times \frac{3}{2}\left\{1 + 0.08\right\} +$$

$$\frac{6}{12.57} \times \frac{3}{2} \times 178.5 \times \frac{1}{4} \times \frac{1}{20 \times 20} \times 1.077^3$$

$$= 1.6 + 0.172 + 0.1 = 1.872$$

$$H_{max} = \frac{pl}{5Nn} = \frac{500 \times 200 \times 10}{5 \times 1.872 \times 1} = 107{,}000 \text{ lb.}$$

* Equation 167 in "Practical Treatise on Suspension of Bridges" by D. B. Steinman, John Wiley & Sons, Inc. 1945.

(iii) Horizontal thrust due to temperature variation

$$H_t = -\frac{3ELI\psi t^*}{f^2 N l}$$

$$\frac{L}{l} = (1 + \frac{8}{3}n^2) + 2\frac{l_1}{l} \text{ Sec. } \alpha$$

L = total length of cable between anchorages

$= 1 + 0.026 + 0.538 = 1.564$

$$H_t = \pm \frac{3 \times 11720 \times 178.5 \times 1.564}{20 \times 20 \times 1.872} = \pm 13{,}100 \text{ lb.}$$

Total value of H is, therefore, obtained by adding the different values of H:

(i)	Due to dead load	125,000 lb.
(ii)	Due to live load	107,000 ,,
(iii)	Due to temperature variation	13,100 ,,
	Total	245,100 ,, = 110 tons.

Max. tension in cable $= H \text{ Sec } \alpha$

$= 110 \times 1.077 =$ say 120 tons.

According to Steinman, the **ultimate** strength of galvanised steel suspension bridge ropes is given by 80,000 (dia)^2 lb.

Strength of one 2 in. dia. wire rope $= 80{,}000 \times 4 = 142$ tons.

Taking a factor of safety of 4

Safe strength of one 2 in. dia. rope = 35 tons.

Safe strength of four 2 in. dia. ropes = 140 tons.

Hence the assumed cable section is quite safe. Actually, 4 cables of 1½ in. dia. on each side may be used.

5. STIFFENING GIRDER

Live load = p = 500 lb per linear foot per truss.

* Equation 156 in "Practical Treatise on Suspension of Bridges" by D. B. Steinman, John Wiley & Sons, Inc. 1945.

(i) **Bending Moment**: With the main span completely loaded the bending moment, M, at any section X is given by*

$$M = \frac{p \times x}{2} (l - x) \left[1 - \frac{8}{5N} \right]$$

$$- \frac{px}{2} (l - x) \quad (0.145)$$

Total moment at the centre where $x = \frac{l}{2}$

$$= \frac{pl^2}{8} \times 0.145$$

$$= \frac{500 \times 200 \times 200}{8} \times 0.145$$

$$= 362{,}500 \text{ ft-lb.}$$

At other points, the values of the moment are proportional to the ordinates of a parabola:

$$Y = \frac{4fx}{l^2} \left(l - x \right)$$

$$= \frac{4x}{l} \left(l - \frac{x}{l} \right) f$$

They are obtained as follows:

Section $\frac{x}{l}$	Parabolic coefficient	Total M ft-lb
0	$4 \times 0 \times 1 = 0$	0
0.1	$4 \times .1 \times .9 = .36$	130,500
0.2	$4 \times .2 \times .8 = .64$	232,000
0.3	$4 \times .3 \times .7 = .84$	304,500
0.4	$4 \times .4 \times .6 = .96$	348,000
0.45	$4 \times .45 \times .55 = .99$	358 500
0.5	$4 \times .5 \times .5 = 1.00$	362,500

* Equation No. 169 in "Practical Treatise on Suspension Bridges" by D. B. Steinman, John Wiley & Sons, Inc. 1945.

For maximum and minimum moments, the critical points are found by solving Equation*

$$C(k) = N.\, n.\, \frac{x}{y} = .1872 \frac{x}{y}$$

The values of the minimum moments are then given by*

$$\text{Min. } M = \frac{-2\, px\,(l-x)}{5N} D(k) = \frac{-4}{5N-8} (\text{Total } M).\, D(k)$$

$$= -2.94 (\text{Total } M).\quad D(k)$$

The graph, Plate V ** is used in solving the values of $C(k)$ for k and then finding the corresponding values of $D(k)$. The following tabulation shows the successive steps:

$\frac{x}{l}$	$\frac{y}{l}$	$\frac{x}{y}$	$C(k)$	k	$D(k)$	Min. M ft-lb
0	0	–	–	–	–	–
.1	.036	2.78	.520	.415	.38	– 146,000
.2	.064	3.12	.584	.465	.28	– 191,000
.3	.084	3.57	.667	.530	.17	– 152,000
.4	.096	4.17	.780	.635	.065	– 66,500
.45	.099	4.55	.850	.70	.03	– 31,600
.5	.100	5.00	.935	.80	.01 + ·01	– 21,300

For all sections between $x = \frac{N}{4} l = 0.468\, l$ and the symmmetrical point $x = 0.532\, l$, a correction is made in the above Table for the second critical point (wherever the values are appreciable)

* Equations 142 and 170 in "Practical Treatise on Suspension Bridges" by D. B. Steinman, John Wiley & Sons, Inc. 1945.

** Reproduced from "A Practical Treatise on Suspension Bridges" – D. B. Steinman, p. 39, with due acknowledgements.

The maximum moments are obtained as follows:

Max. M = Total M − Min. M

Section $\frac{x}{l}$	Max. M ft-lb
0	– –
0.1	+ 276,500
0.2	+ 423,000
0.3	+ 456,500
0.4	+ 414,500
0.45	+ 390,100
0.5	+ 383,800

The moments produced by temperature variation are given by:

$$M_t = - H_t \times y$$

H_t see page 361 = ± 13,100. Therefore, at the centre:

$$M_t = \pm 13100 \times 20 = \pm 262000 \text{ ft-lb.}$$

At other sections, the moments are proportional to the parabolic ordinates y:

Section $\frac{x}{l}$	Parabolic coefficient	M_t ft-lb
0	–	–
.1	.36	± 94,000
.2	.64	± 168,000
.3	.84	± 220,000
.4	.96	± 253,000
.5	1.00	± 262,000

(The plus sign pertains to rise in temperature, the minus sign to a fall of temperature.

The resulting stresses are then combined with live load stresses previously found.

Maximum moment is at $\frac{x}{l} = 0.3 = 456{,}500$ ft−lb.

Moment due to temperature variation = 220,000 ,, ,,

Total = 676,500 ft−lb.

Considering the lorry load only

Lorry load = 10.0 tons

Total load with 50 per cent impact = 15.0 tons

Load per truss = 7.5 tons

$$H \text{ (maximum)} = \frac{5}{16} \times \frac{P}{Nn} = \frac{5}{16} \times \frac{7.5 \times 2240}{1.872} \times 10$$

$$= 28{,}000 \text{ lb}$$

Bending moment at centre $= M_l - H \times y_c$

$$= \frac{Pl}{4} - H \times y_c$$

$$= \frac{7.5 \times 2240 \times 200}{4} - 28{,}000 \times 20$$

$$= 280{,}000 \text{ ft-lb.}$$

For a concentrated load the maximum bending moment will be at quarter point and works out to 330,300 ft-lb in this case.

These values are less than that found with a U.D.L. of 100 lb per sq. ft.

Hence stress in chord $= \frac{\text{Total B.M.}}{\text{Depth of truss}}$

$$= \frac{6{,}76{,}500}{6 \times 2240} = \text{say } 50 \text{ tons}$$

Tension Flange

Net area required $= \frac{50}{8} = 6.25$ sq. in.

Provided 2 angles = 6 in. × 6 in. × ½ in.

Area of one angle = 5.75 sq. in.

Deducting area of say two rivet holes:

Net area = 5.75 − 0.81 = 4.94 sq. in.

Area provided = 2 × 4.94 = 9.88 sq. in

Area in excess can be used for taking wind stresses, see para 6.

Compression Flange

To prevent bulking of the compression member:

$\frac{L}{r}$ should not be greater than 125

where r = least radius of gyration.

Area of two angles 6 in. × 6 in. × 3/8 in. = 2 × 4.36
= 8.72 sq. in.

Least radius of gyration about $X-$axis = 1.18

Therefore, safe length against bulking $= \frac{125 \times 1.18}{12}$
= 12.30 ft

Here L = 5 ft and is, therefore, safe.

Safe compressive stress $= 16{,}000 - 70\,\frac{L}{r}$

$= 16{,}000 - 70 \times \frac{60}{1.18}$

= 5.6 tons

Area required $= \frac{50}{5.6}$ = 8.9 sq. in.

Area provided, 2 angles 6 in. × 6 in. × 3/8 in.,
= 8.72 sq. in.

(ii) **Shears in Stiffening Truss**

(p = 500 lb per linear ft; 1/2 pl = 50,000 lb)

With the main span fully loaded, the shears at the various sections are given by

$$\text{Total } V = \tfrac{1}{2}\, p\,(l - 2x)\left(1 - \frac{8}{5N}\right) = \tfrac{1}{2}\, pl\left(1 - \frac{2x}{l}\right)(0.145)$$

$$= 7250\left(1 - \frac{2x}{l}\right)$$

Section $\frac{x}{l}$	$1 - \frac{2x}{l}$	Total V lb
0	1	7250
.1	.8	5860
.2	.6	4350
.3	.4	2900
.4	.2	1450
.5	0	0

The maximum shears are given by *

$$\text{Max. } V = \tfrac{1}{2}\, pl\left(1 - \frac{x}{l}\right)^2\left[1 - \frac{8}{N}\left(\frac{1}{2} - \frac{x}{l}\right)\cdot\ G\left(\frac{x}{l}\right)\right]$$

$$= \tfrac{1}{2}\, pl\left(1 - \frac{x}{l}\right)^2 Q$$

The values of $G\left(\frac{x}{l}\right)$ are taken from the graph, Plate V and the shears are obtained as follows:

Section $\frac{x}{l}$	$\left(1 - \frac{x}{l}\right)^2$	$\frac{8}{N}\left(\frac{1}{2} - \frac{x}{l}\right)$	$G\left(\frac{x}{l}\right)$	Q above	Maximum V lb
0	1	2.14	.400	.144	7200 + 9980 = 17,180
.1	.81	1.71	.482	.175	7100 + 4650 = 11,750
.2	.64	1.28	.565	.277	8860 + 930 = 9,790
.3	.49	0.85	.647	.450	11000
.4	.36	0.43	.726	.688	12400
.5	.25	0	.800	1.000	12500

* Equation 149 in "Practical Treatise on Suspension Bridges" by D.B. Steinman, John Wiley & Sons, Inc. 1945.

For all sections $x < \frac{l}{2}\left(1 - \frac{N}{4}\right) = .266\ l$, the loading for maximum shear extends from the given section X to a critical point kl defined by:

$$C(k) = \frac{N}{4}\,\frac{l}{l - 2x} = \frac{.468}{1 - \frac{2x}{l}}$$

The values $C(k)$ are solved for k with the aid of graph, Plate V.

Section	$1 - \frac{2x}{l}$	$C(k)$	K
0	1	.468	.380
.1	.8	.585	.465
.2	.6	.780	.635

For these sections, a correction is to be added to the values of Max. V found above. This additional shear is given by*

$$\text{Additional } V = \tfrac{1}{2}\,pl\,(1-k)^2\left[\frac{8}{N}\left(\frac{1}{2} - \frac{x}{l}\right)G(k) - 1\right]$$

$$= \tfrac{1}{2}\,pl\,(1-k)^2\,Q^1$$

Section $\frac{x}{l}$	k	$(1-k)^2$	$\frac{8}{N}\left(\frac{1}{2} - \frac{x}{l}\right)G(k)$	Q above	Addl. V (lb)
0	.380	.384	2.14	.710	.520	9,980
.1	.465	.286	1.71	.775	.325	4,650
.2	.635	.133	1.28	.890	.140	930

The minimum shears are then given by:

Min. V = Total V − Max. V.

* Equation 151 in "Practial Treatise on Suspension Bridges" by D.B. Steinman, John Wiley & Sons, Inc. 1945.

Section $\frac{x}{l}$	Total V	Maximum V	Minimum V
0	7250	17180	− 9930
.1	5800	11750	− 5950
.2	4350	9790	− 5440
.3	2900	11000	− 8100
.4	1450	12400	− 10950
.5	0	12500	− 12500

The temperature shears are given by:

$V_t = -H_t \tan \phi$ where ϕ is the inclination of the cable at any section.

$H_t = \pm$ 13,100 lb

At the ends, $\tan \phi = \frac{4f}{l} = 4n = 0.40$

and the slope ($\tan \phi$) diminishes uniformly toward the crown.

$$y = \frac{4fx}{l}\left(1 - \frac{x}{l}\right)$$

$$\frac{dy}{dx} = \tan \phi = \frac{4f}{l}\left(1 - \frac{2x}{l}\right)$$

Section $\frac{x}{l}$	$\tan \phi$	V_t
0	0.40	± 5,240
.1	.32	± 4,180
.2	.24	± 3,140
.3	.16	± 2,096
.4	.08	± 1,048
.5	0	0

Combining the maximum temperature shear with the maximum live load shear, we have:

Maximum Shear

Due to live load	= 17,180 lb
Due to temperature	= 5,240 ,,
	22,420 ,,
	= 10 tons

Taking safe shear stress as 5 tons per sq. in.

Area required $= \frac{10}{5} = 2$ sq. in.

Gross area of 2 angles 2½ in. × 2½ in. × 1/4 in. = 2.38 sq. in

Hence section provided is safe.

Area required for diagonal members.

$$= 2 \times \frac{7.8}{6} = 2.6 \text{ sq. in.}$$

Hence provide 2 angles 2½ in. × 2½ in. × 5/16 in.

Gross area = 2.92 sq. in.

Deflection of Stiffening Truss

For a uniform load p covering the full span, the resulting deflection will be given by :

$$d = \frac{5}{384}\left(1 - \frac{8}{5N}\right)\frac{pl^4}{EI}$$

$$= \frac{5}{384} \times 0.145 \times \frac{500 \times 200^4}{30 \times 10^6 \times 178.5}$$

$$= 0.282 \text{ ft}$$

6. WIND STRESSES IN BOTTOM CHORDS

If the lateral bracing is in the plane of the bottom chords these chords act as the chords of a wind truss. The applied wind pressure p is partly counteracted by a force of restitution r due to the horizontal displacement of the weight of the stiffening truss w. The resulting reduction in the effective horizontal load is given with sufficient accuracy by the formula.*

$$\frac{r}{p} = \frac{\frac{.013\ wl^4}{vEI}}{1 + \frac{.013\ wl^4}{vEI}}$$

* For the derivation of this formula, refer Steinman's "Suspension Bridges and Cantilevers", D. Van Nostrand Co., 1913, page 76.

where, w = total dead load (both trusses) = 1000 lb.

v = vertical height from cable chord to centre of gravity of dead load = say 22 ft approx.

I = moment of inertia of wind truss

$= \frac{1}{2} \times 11.5 \times 12^2 = 828 \text{ in.}^2 \text{ ft}^2$.

$E = 30 \times 10^6$

Substituting,

$$\frac{0.013\ wl^4}{vEI} = \frac{0.013 \times 1000 \times 200^4}{22 \times 30 \times 10^6 \times 828}$$

$$= 0.038$$

$$\frac{r}{p} = \frac{0.038}{1.038} = 3.66 \text{ per cent.}$$

Area exposed to wind:

Top flange	$= \frac{1}{2} \times 200$	= 100 sq. ft.
Bottom flange	$= \frac{1}{2} \times 200$	= 100 ,,
Decking	$= \frac{1}{2} \times 200$	= 100 ,,
Diagonals	$= \frac{40 \times 2 \times 2\frac{1}{2} \times 2 \times 7.8}{12}$	= 260 ,,
Verticals	$= 40 \times \frac{2 \times 2\frac{1}{2}}{12} \times 6$	= 100 ,,
	Total :	660 ,,

Total wind pressure = 660 × 1½ × 50 = 49,500 lb

Wind load per foot run (p) = 247 lb

$$\frac{r}{p} = .0366$$

$$r = 247 \times .0366 = 9.05$$

The force of restitution r (due to the obliquity of suspension after horizontal deflection) amounts, in this case, to 3.66 per cent

of the applied wind load (p) at the centre of the span. The force r diminishes to zero at the ends of the span, and the equivalent uniform value of r may be taken as 5/6 of the mid-span value. The resultant horizontal load on the span is :

$$p - \frac{5}{6} r = 247 - \frac{5}{6} \times 9.05 = 240 \text{ lb. per linear ft}$$

B.M. at the centre $M_w = \frac{240\ l^2}{8} = 1200000$ ft-lb.

Stress in chord due to wind load $= \frac{1200000}{12 \times 2240} = 44.5$ tons.

Total stress in bottom chord :

Due to live load and temperature effect = 50 tons.

Due to wind load = 44.5 ,,

94.5 tons.

Net area required increasing the allowable stress by 25 per cent

$= \frac{94.5}{10} = 9.45$ sq. in.

Area provided = 9.88 sq. in.

Wind Bracing

Maximum shear at the end

$$= \frac{240 \times 200}{2} = 24000 \text{ lb}$$

Force in diagonal $= 24000 \times \frac{13}{12} = 26000$ lb

Area required $= \frac{26000}{5 \times 2240} = 2.32$ sq. in.

Provide 2 angles 2½ in. × 2½ in. × 5/16 in.

Gross area = 2.92 sq. in.

7. SUSPENDERS

Maximum load taken by one suspender :

Dead Load

		lb
1 in. thick carpet	$= \frac{1}{12} \times \frac{10}{2} \times 5 \times 150 =$	312.5
5 in. thick planking	$= \frac{5}{12} \times \frac{12}{2} \times 5 \times 36 =$	450.0
Wheel guard	$= \frac{3}{4} \times 1 \times 5 \times 36 =$	135.0
Stringers	$= 2 \times 20 \times 5 =$	200.0
Stiffening girder		= 700.0
Cross beam 9 × 40		= 360.0
	Total :	2157.5 lb
		= or 1 ton.

Live Load

Weight of rear axle of truck = 10 × .8 = 8 tons.

With 50 per cent impact = 12 tons.

Weight of one wheel = 6 tons.

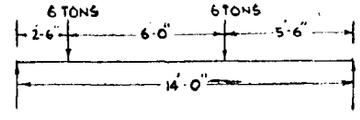


Fig. 5.

Weight on one suspender as per sketch above :

$$6 \times \frac{11.5}{14} + 6 \times \frac{5.5}{14} = 6 \times \frac{17}{14} = 7.3 \text{ tons.}$$

Total load on one suspender = 7.3 + 1.00 = 8.3 tons.

Area required per suspender $= \frac{8.30}{8} = 1.04$ sq. in.

Use 1¼ in. dia. rods, area = 1.227 sq. in,

8. SIZE OF ANCHORAGES

Maximum tension in cable = 120 tons

Horizontal component (H) = 110 tons

$\therefore$ Vertical component $= \sqrt{120^2 - 110^2}$

$= \sqrt{230 \times 10} = 48$ tons

Taking coefficient of friction (u) (rocky base) $= 0.7$

Vertical load required to counteract H $= \frac{H}{u} = \frac{110}{.7} = 157$ tons.

Total upward pull to be counteracted $= 157 + 48 = 205$ tons

With a factor of safety of 2 weight of concrete block or masonry required $= 2 \times 205 = 410$ tons

Volume of masonry required $= \frac{410 \times 2240}{140} = 6550$ cu. ft.

Provide 30 ft × 22 ft × 10 ft to give 6600 cu. ft.

or 20 ft × 30 ft × 12 ft giving 7200 cu. ft.

Appendix 3

ABSTRACT OF COST

S. No.	Item of work	Amount Rs
1.	Approaches, see page 402	6,180
2.	Abutment and towers complete, see page 402	20,770
3.	Decking and superstructure, see page 403	81,200
4.	Miscellaneous, see page 404	2,250
5.	Anchorage complete, see page 404	42,050
		1,52,450
	Add 3 per cent contingencies on Rs 1,52,450	4,573
	Add 2 per cent petty work charged establishment on Rs 1,57,023	3,140
	Total	1,60,163

Appendix 3 (*Contd.*)

No.	Approaches	Quantity	Rate Rs	Per	Amount Rs
1.	Stone filling with stone available within 2 chains	12000 cu. ft.	6	100 cu. ft.	720
2.	Coursed rubble hammer dressed masonry laid dry in retaining wall with stone available within one chain	15600 cu. ft.	35	do.	5460
	Total				6180
	Abutments and Towers				
1.	Excavation in foundation in pick jumper and blasting work upto depth including removal of spoil up to 100 feet	Job			1000
2.	Coursed rubble hammer dressed masonry laid in cement mortar 1 : 4 including carriage of stone up to one furlong for abutment and foundation below road level	Job			10000
3.	Coursed rubble hammer dressed stone masonry laid in cement morter 1 : 6	5500 cu. ft.	118	100 cu. ft.	6490
4.	Cement concrete 1 : 6 : 18 with 40 per cent plumb work	785 cu. ft.	90	do.	706
5.	R.C.C. 1 : 2 : 4 complete including cost of steel reinforcement centring and shuttering etc. complete having 7 lb of steel	120 cu. ft.	4-12-0	do.	570
6.	Ashler stone masonry in cement mortar 1 : 3 in arches including carriage of stone up to one furlong	64 cu. ft.	24-8-0	do.	1568
7.	Cement pointing 1 : 2 on the stone work	2510 sq. ft.	13-8-0	100 sq. ft.	340
8.	Dry boulder filling in cement concrete 1 : 6 : 18	523 cu. ft.	18	100 cu. ft.	94
	Total				20,768
				say Rs	20,770

Appendix 3 (*Contd.*)

Decking and Superstructure

S. No.		Quantity	Rate Rs	Per	Amount Rs
1.	Mild steel work wrought, framed and fixed in position including finishing and painting 3 coats with best quality paint	68 cwt.	36	cwt.	2448
2.	Mild steel work in heavy section including finishing and painting 3 coats complete	1452 cwt.	29	cwt.	42108
3.	Wire ropes of 1½ in. dia. including lifting and fixing in position complete at 4.67 lb	133.43	60	—	8005
4.	Plate clamps for 1¼ in. dia. suspender complete	80 No.	30	each	2400
5.	M. S. iron grips for 1½ in. dia. steel cables	128 No.	15	each	1920
6.	1¼ in. dia. suspenders	38.75 cwt.	28	cwt.	1085
7.	Steel pulley 10 in. dia. complete with bolts and nuts	16 No.	100	each	1600
8.	2½ in. dia. Anchorage bolts and nuts complete	32 No.	3	each	96
9.	Saddles complete with all respects	4 No.	1200	each	4800
10.	Mild steel hacks for 1½ in. dia. suspender	80 No.	20	each	1600
11.	Deodar wood work wrought framed and fixed in position	1140 cu. ft.	6	cu.ft.	6840
12.	Extra carriage of iron ropes and steel from Delhi to site of work	Job			8000
13.	Solignum painting 2 coats				300
				Total	81,202
				say Rs	81,200

Appendix 3 (*Contd.*)

Miscellaneous

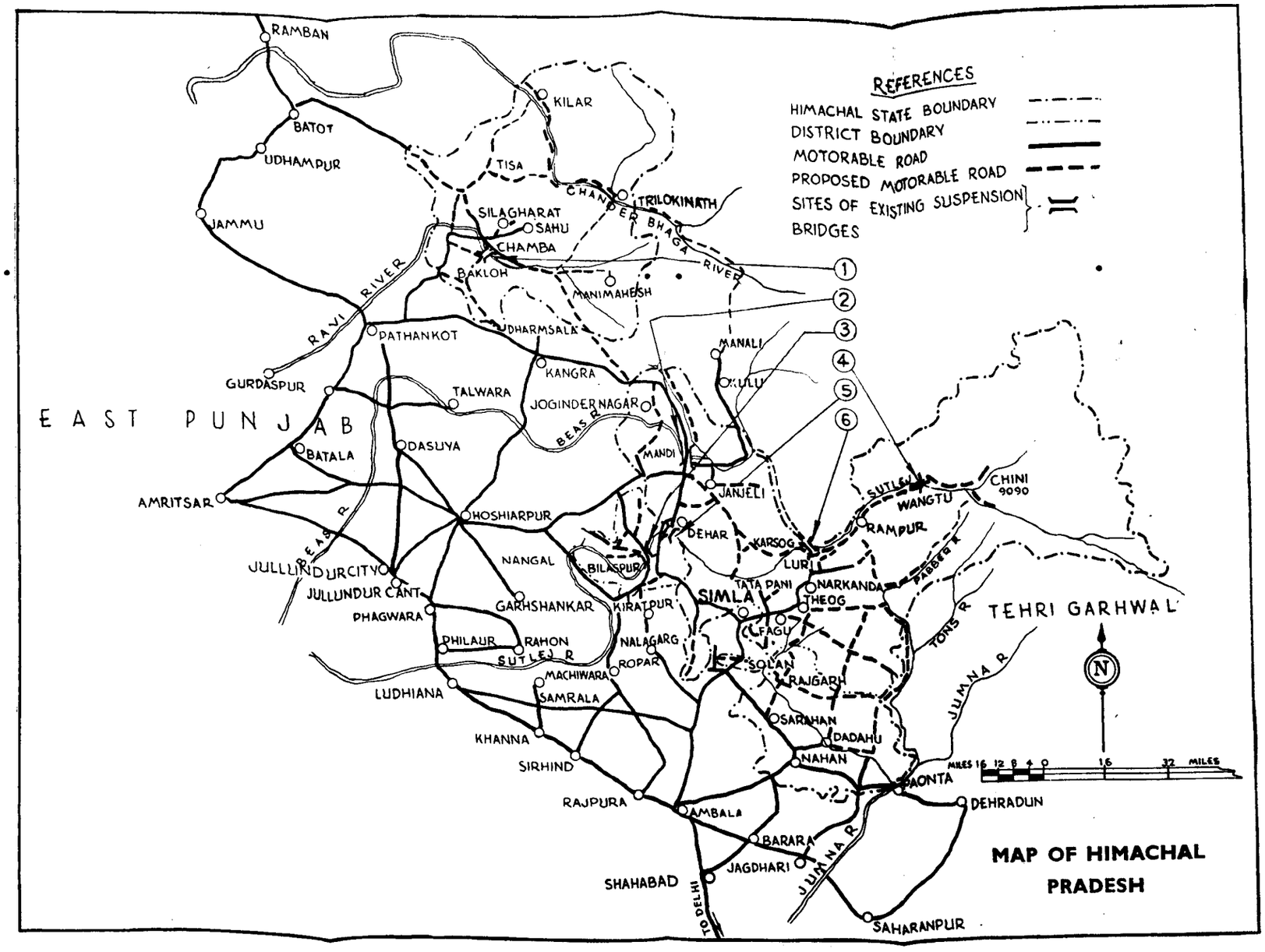
S. No.		Quantity	Rate	Per	Amount
1.	Providing and maintenance of Jhulla	...			Rs 250
2.	Extra carriage of stone load etc.	...			2000
			Total		2,250

Anchorage

1.	Excavation of foundation jumper and blasting work including removal of spoil upto 100 ft	31920 cu. ft	125	100 cu. ft.	3989
2.	Cement concrete 1 : 3 : 6 in foundation	4486 cu. ft.	126	do.	5645
3.	Coursed rubble hammer dressed masonry laid in cement mortar 1 : 6 including carriage of stone upto one furlong	17300 cu. ft.	108	do.	18684
4.	Trap doors complete in all respects	...			400
5.	Cement pointing 1 : 2	3024 sq. ft.	13/8	100 sq. ft.	408
6.	Cement concrete 1 : 6 : 18 with 40 per cent plum work	12672 cu. ft.	90	100 cu. ft.	11404
7.	Dry stone filling in 40 per cent plum work	8448 cu. ft.	18	do.	1521
		Total			42,051

or say Rs 42,050

PLATE I


REFERENCES
HIMACHAL STATE BOUNDARY
DISTRICT BOUNDARY
MOTORABLE ROAD
PROPOSED MOTORABLE ROAD
SITES OF EXISTING SUSPENSION BRIDGES
EAST PUNJAB
RAMBAN
BATOT
UDHAMPUR
JAMMU
KILAR
TISA
TRILOKINATH
CHANDER BHAGA RIVER
SILAGHARAT
SAHU
CHAMBA
BAKLOH
MANIMAHESH
RAVI RIVER
PATHANKOT
DHARMSALA
GURDASPUR
TALWARA
KANGRA
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BILASPUR
JULLUNDUR CITY
JULLUNDUR CANT
PHAGWARA
GARHSHANKAR
KIRATPUR
TATA PANI
NARKANDA
THEOG
SIMLA
FAGU
SOLAN
RAJGARH
PABBER R
TONS R
TEHRI GARHWAL
JUMNA R
PHILAUR
RAHON
SUTLEJ R
NALAGARG
ROPAR
MACHIWARA
LUDHIANA
SAMRALA
KHANNA
SIRHIND
RAJPURA
AMBALA
SARAHAN
DADAHU
NAHAN
PAONTA
DEHRADUN
BARARA
JAGDHARI
SHAHABAD
TO DELHI
SAHARANPUR
N
MILES 16 12 8 4 0 16 32 MILES
MAP OF HIMACHAL PRADESH

PLATE II

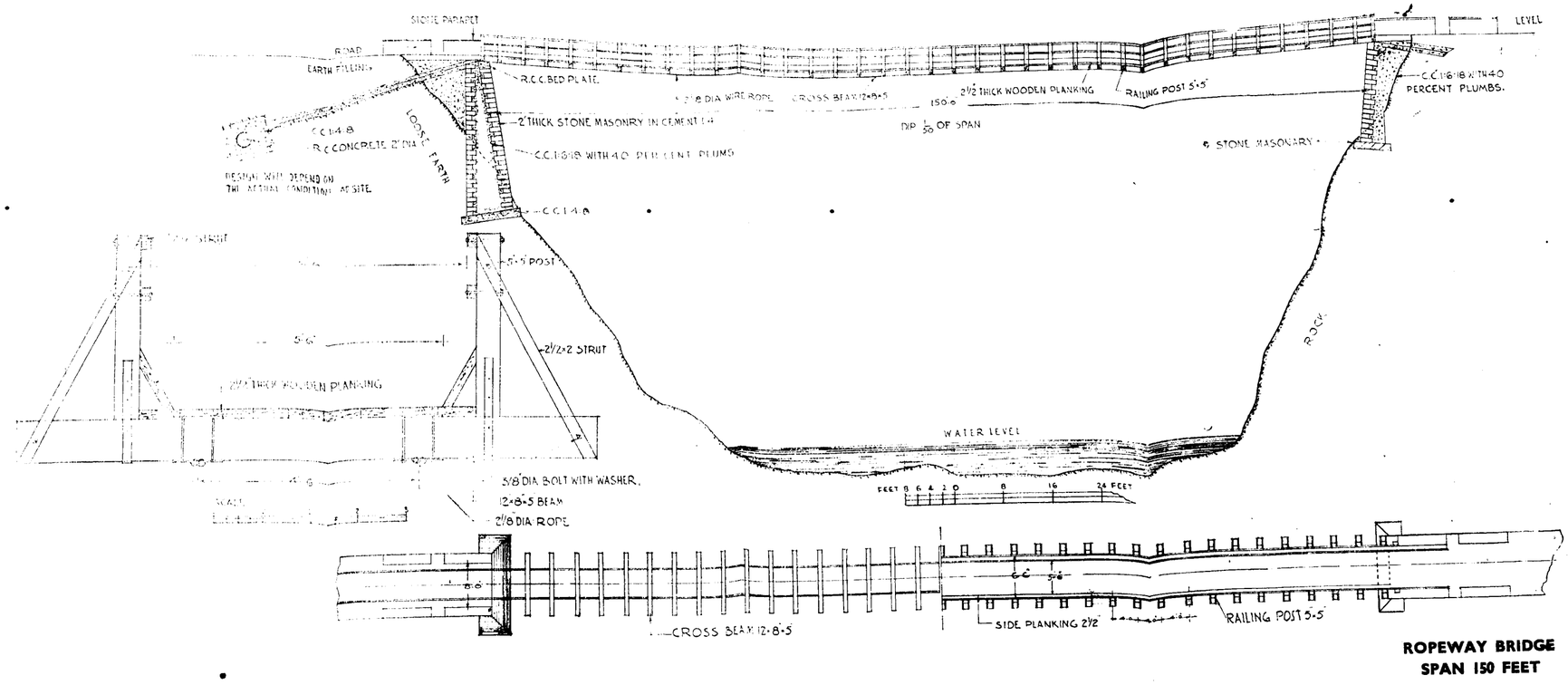
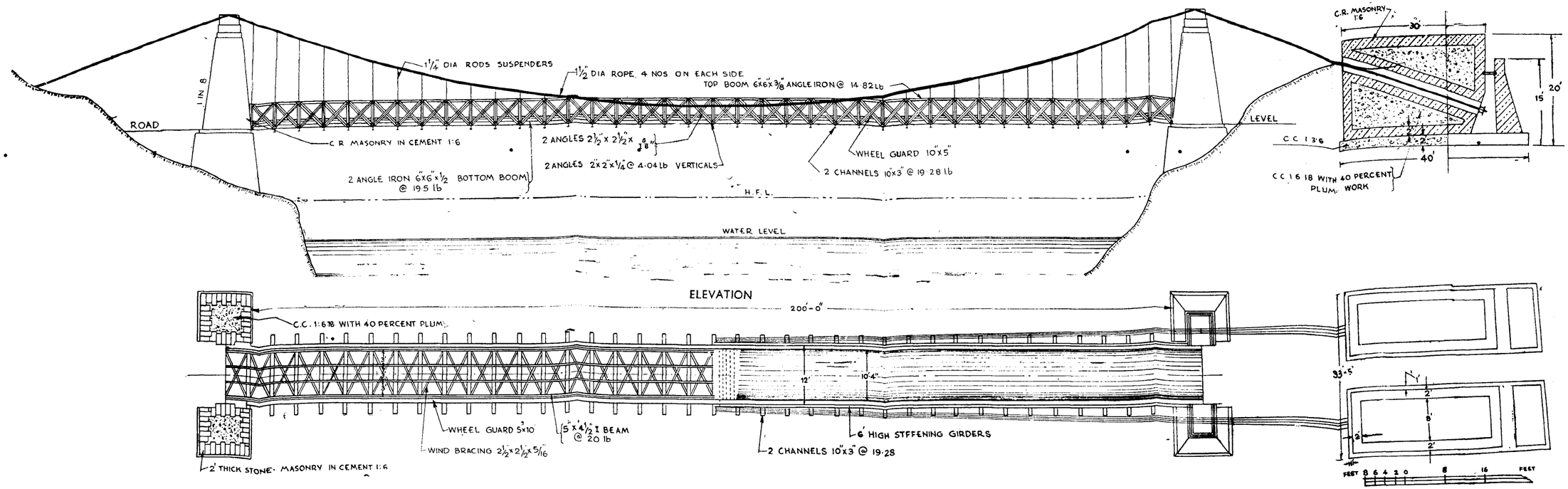

STONE PARAPET
ROAD
EARTH FILLING
LEVEL
R.C.C. BED PLATE
⅝" DIA WIRE ROPE
CROSS BEAM 12×8×5
150·0
2½ THICK WOODEN PLANKING
RAILING POST 5·5
C.C. 1:6:18 WITH 40 PERCENT PLUMBS.
2' THICK STONE MASONRY IN CEMENT 1:4
DIP 1/50 OF SPAN
C.C. 1:6:18 WITH 40 PER CENT PLUMB
C.C. 1:4:8
R.C.C. CONCRETE 2' DIA
LOOSE EARTH
DESIGN MAY DEPEND ON THE ACTUAL CONDITIONS AT SITE
STONE MASONARY
ROCK
5·5 POST
5·6
2½×2 STRUT
2½" THICK WOODEN PLANKING
WATER LEVEL
FEET 8 6 4 2 0 8 16 24 FEET
SCALE
⅝" DIA BOLT WITH WASHER.
12×8×5 BEAM
⅝" DIA ROPE
CROSS BEAM 12·8·5
SIDE PLANKING 2½
RAILING POST 5·5
ROPEWAY BRIDGE
SPAN 150 FEET

PLATE III

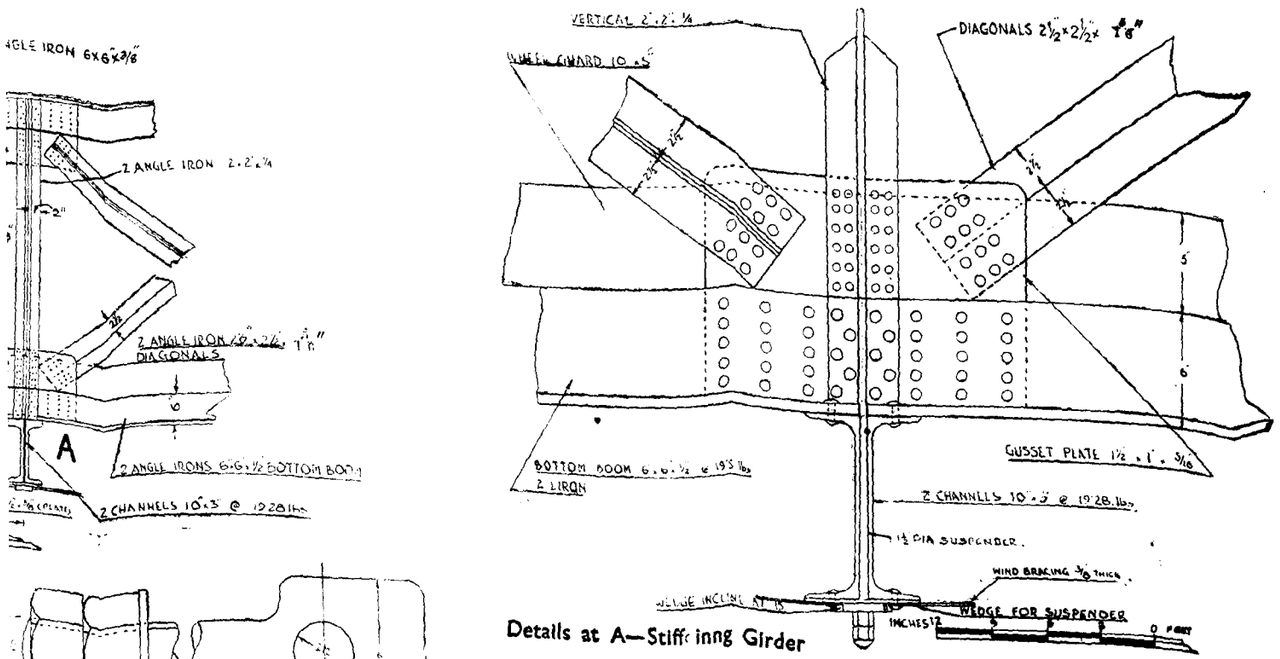


HALF PLAN WITHOUT ROADWAY PLANKING

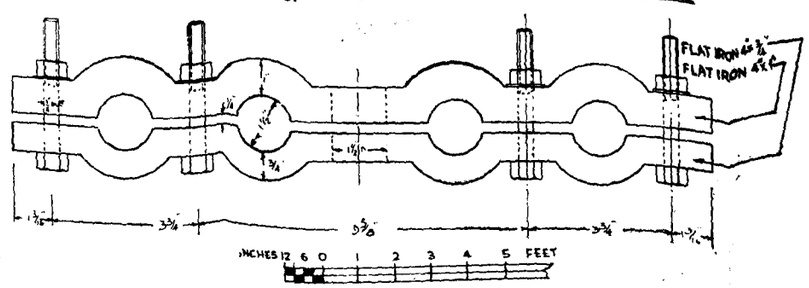
HALF PLAN WITH ROADWAY PLANKING

TYPICAL DESIGN FOR A 200 FT SUSPENSION BRIDGE

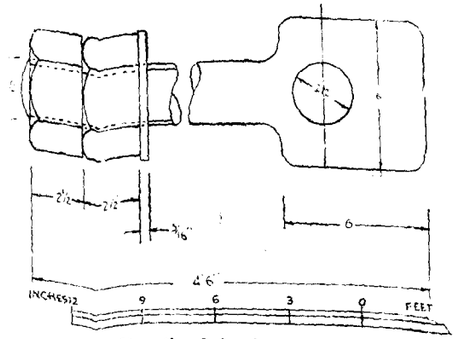
PLATE I'



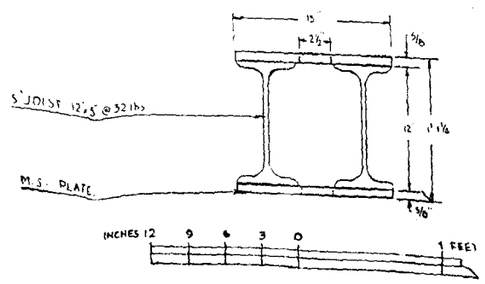
Details at A—Stiffe inng Girder



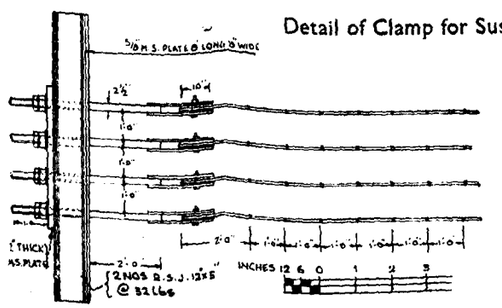
Detail of Clamp for Suspender



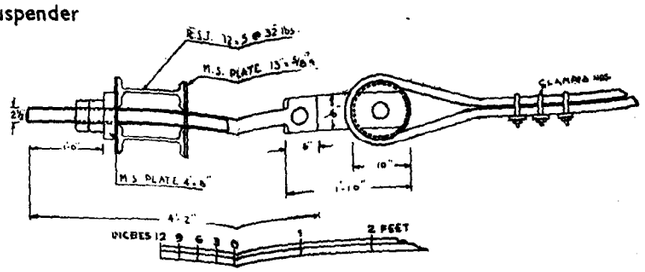
Detail of Anchorage Bolt



Details of Box Girder

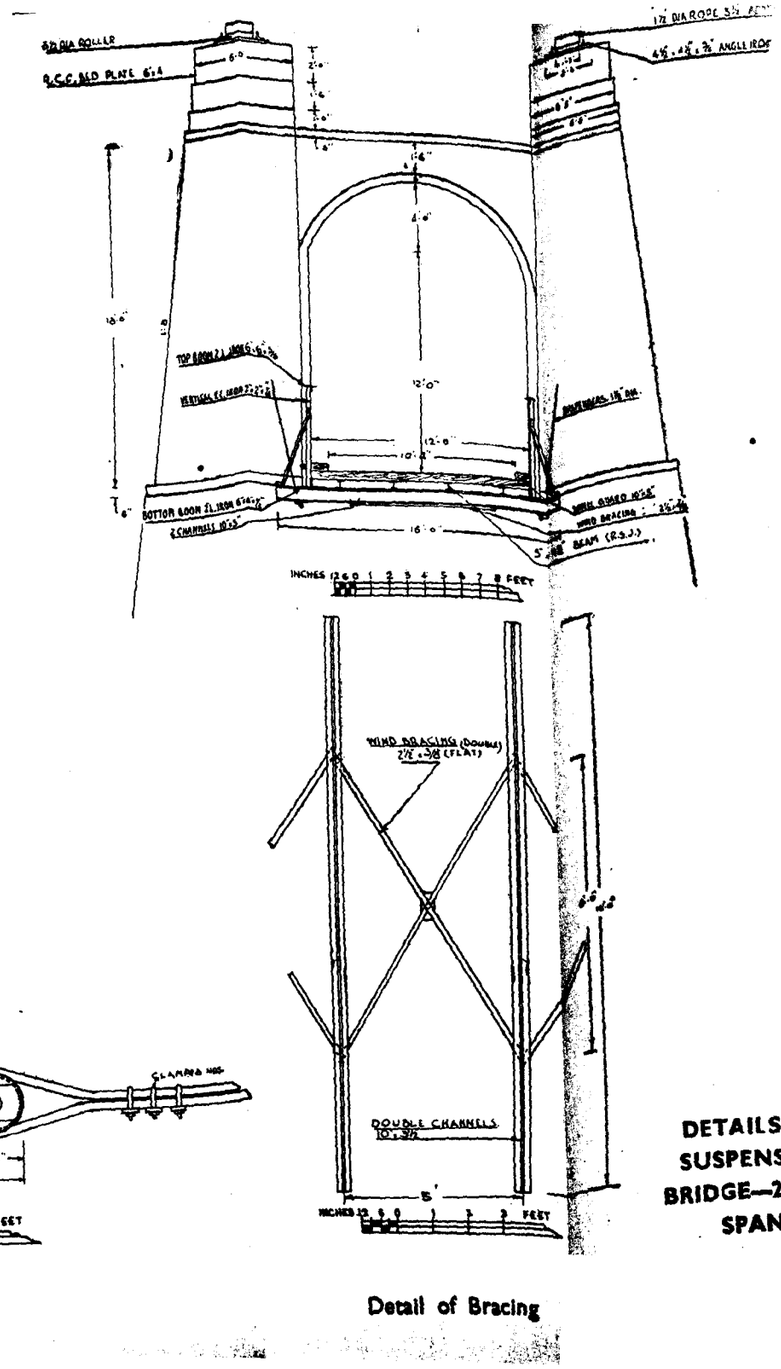


Plan



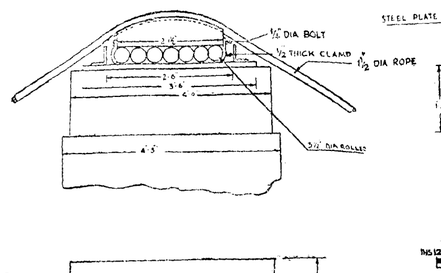
Details of Anchorages

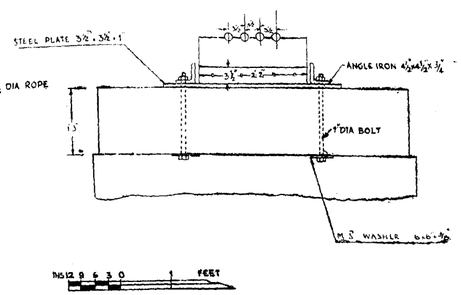
Section



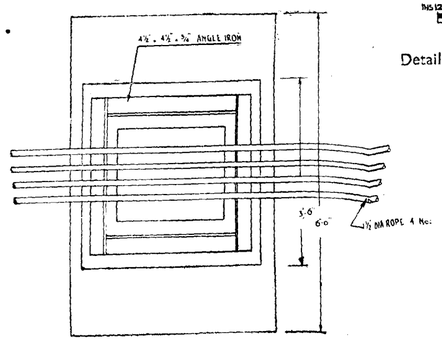
Detail of Bracing

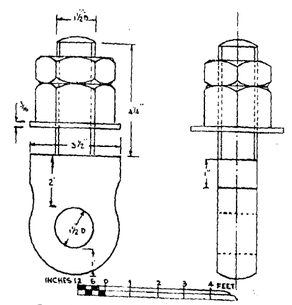
DETAILS OF SUSPENSION BRIDGE—200 FT SPAN



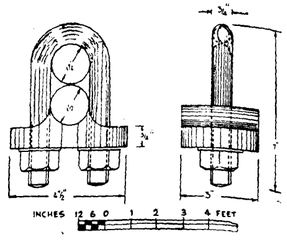


Detail of Saddle

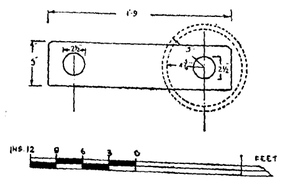




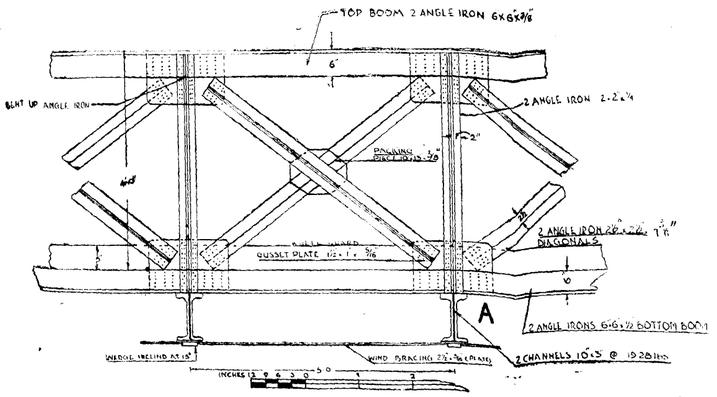
Detail of Hook for Suspenders



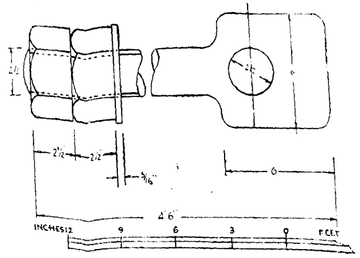
Detail of Wire Rope Grip



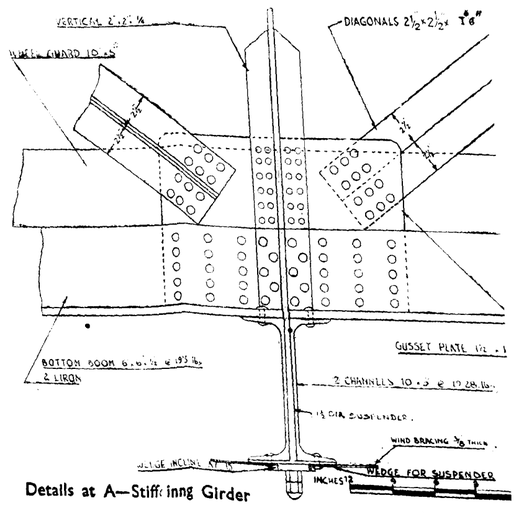
Detail of M. S. Plate Joining Anchor. Bolt & Pulley



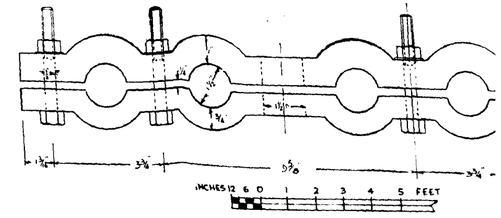
Details of Stiffening Girder



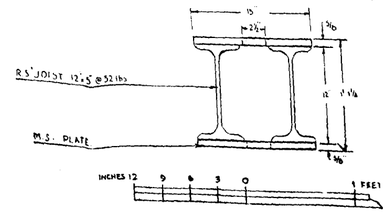
Detail of Anchorage Bolt



Details at A—Stiffening Girder

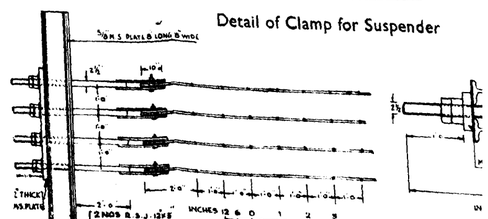


Detail of Clamp for Suspender



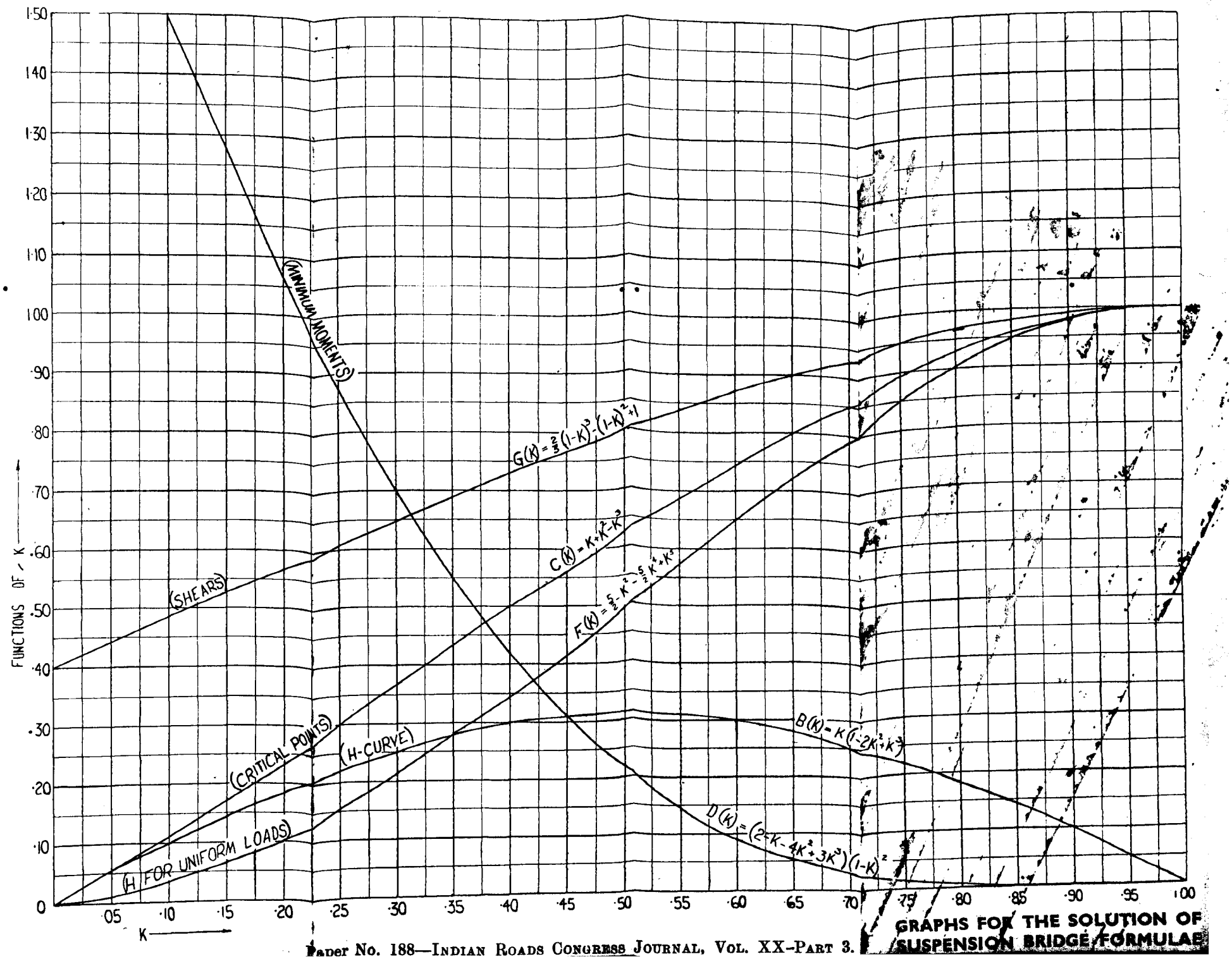
Detail of Steel Pully

Details of Box Girder



Plan

Details of Anchorage


FUNCTIONS OF K
K
(MINIMUM MOMENTS)
(SHEARS)
(CRITICAL POINTS)
(H-CURVE)
(H FOR UNIFORM LOADS)
G(K) = ⅔(1-K)³-(1-K)³+1
C(K) = K+K²-K³
F(K) = 5/2 K²-5/2 K⁴+K⁵
B(K) = K(1-2K²+K³)
D(K) = (2-K-4K²+3K³)(1-K)²
GRAPHS FOR THE SOLUTION OF SUSPENSION BRIDGE FORMULAE

Reprinted from HIGHWAYS AND BRIDGES AND ENGINEERING WORKS,
November 24th, 1954.

New Features for the Merton Overloader

After two years of success in Britain and in the 22 countries to which it has been exported the British made Merton Overloader now has several important new features. As a result of this success Merton Overloaders are now being exported to the United States of America, Canada and parts of South America. The sole concessionaires in the United Kingdom and in the Americas are Mackay Industrial Equipment Ltd., of Faggs Road, Feltham, Middlesex, who tell us that this is the only British construction equipment now being exported to the U. S. A.

The improved Merton Overloader—the only British construction plant being exported to the U.S.A.

The bucket of the new Merton Overloader, Mark V, has a capacity of ¾ cu. yd. and covers the full width of the front wheels of the tractor. This eliminates any tendency for the front wheels to ride up on the material being loaded and also greatly increases the efficiency of the machine when excavating.

The digging depth of the bucket can be adjusted, simply by the removal and replacement of two bolts, to any position between 2 in. above ground level and 4 in. below ground level. The adjustment to 2 in. above the horizontal will simplify the operation of the machine when it is loading a stockpile on uneven ground when it is important that water or foreign matter from the base should not be mixed with the material being loaded.

The discharge height of the Merton Overloader is now variable. A small hand winch, operated by one man, raises and lowers the overhead structure of the machine by extending and retracting the telescopic rear upright members so that the bucket can be discharged at any height from a minimum of 6 ft. 11 in. to a maximum of 11 ft. 2 in. To change from minimum to maximum discharge heights takes only three minutes and entails the removal and replacement of only four bolts. The reach of the bucket, that is the distance from the inside edge of the bucket when in the discharge position to the rearmost part of the tractor (the tyres), is 3 ft. 6 in. when in the minimum discharge position and 2 ft. when in the maximum discharge position.

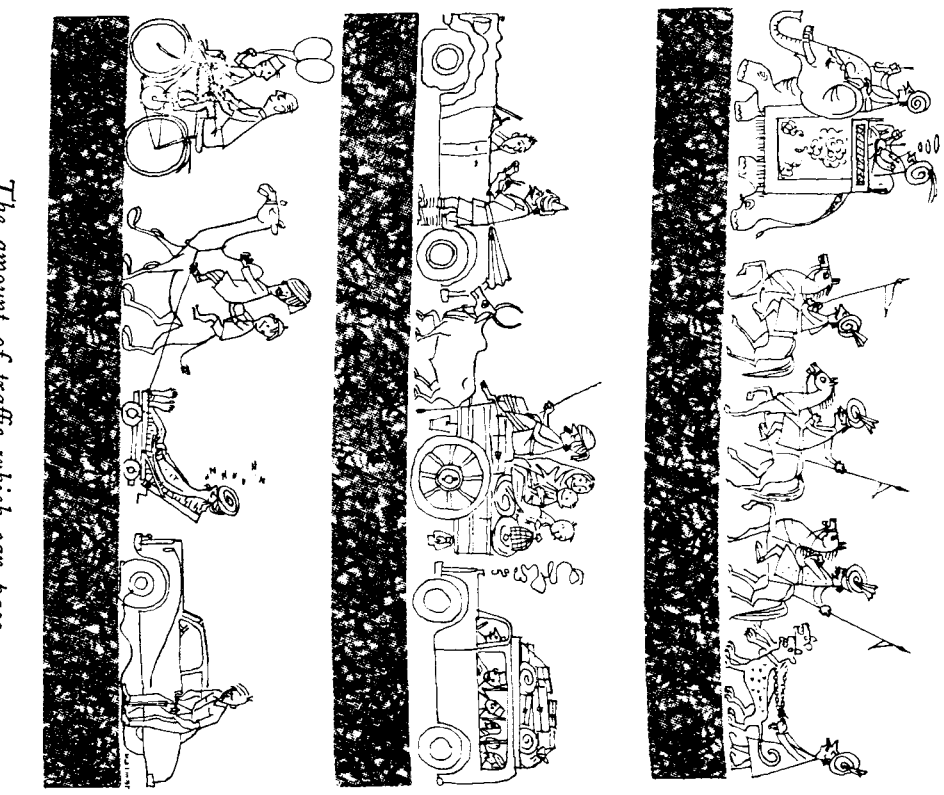
From the minimum discharge position the overhead structure can be lowered still further to the travelling position giving the machine an overall height of 8 ft. 5 in.

An enclosed cab is now a standard fitment on the Merton Overloader. It is constructed of heavy gauge sheet steel and fitted with toughened safety glass windows, which give the operator excellent all round vision. The turning radius of the Mark V Merton Overloader is the same as that of the Mark IV—17 ft. 6 in.

A light materials bucket of 1 cu. yd. capacity is available as an optional extra. Other optional equipments are a 6 ft. 9 in. bulldozer blade and a one ton capacity crane hook attachment.

The Merton Overloader of course, does not turn or slew, it shuttles backwards and forwards in a straight line between stockpile and lorry. The power unit is the Fordson Major diesel engine.

The complete cycle from loading the bucket to discharging and back to loading takes 15–20 sec., and during this time the machine can also travel backwards and forwards a distance of twelve yards. It is claimed that it can load blasted rock at the quarry face at the rate of one ton per minute or sand from a stockpile at the rate of 5 cu. yd. in 2½ minutes.



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Mexphalte
lasts and lasts and lasts and so does
Shelspra

.....BURMAH-SHELL FOR BETTER ROADS.....