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LOW VOLUME ROADS: THIRD INTERNATIONAL CONFERENCE ADDRESSES AND RESEARCH NEEDS

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FOREWORD

The Third International Conference on Low Volume Roads was held at Arizona State University in Tempe, Arizona, July 24 - 28, 1983. The conference theme was new thoughts on appropriate criteria for low volume roads. All papers presented at the conference have been published in Transportation Research Record 898.

This circular contains the text of special addresses made at the conference not published in the TR Record. Included are the keynote address, summaries of the conference from both American and International viewpoints, topic areas of future research identified by a special panel of conferees and summations of informal presentations made to the committee. Errata for papers published in Record 898 are also included.

Financial support for this conference was provided by the Federal Highway Administration and through registration fees. Special thanks are extended to the cooperating agencies who did much to make the conference a success.

Agency for International Development
American Association of State Highway and Transportation Officials
American Road and Transportation Builders Association
Arizona Association of County Engineers
Arizona State University, College of Engineering and Applied Science
Arizona Department of Transportation
International Bank for Reconstruction and Development
International Road Federation
National Association of County Engineers
National Association of County Officials
National Science Foundation
Society of American Foresters
U.S. Army Corps of Engineers Waterways Experiment Station
U.S. Department of Agriculture, Forest Service

KEYNOTE ADDRESS

LOCAL ROAD AND WORLD DEVELOPMENT

Wilfred Owen, The Brookings Institution

Contents and Summary

Nations spend a fairly constant proportion of their resources for transportation. In the competition for these resources, transportation for cities and for intercity facilities are winning out over the less visible needs of low-volume rural roads, which generally get what is left over.

This situation, if allowed to continue, may find the world without adequate supply lines to the cities and without the necessary rural access to make possible the production of food and other resources needed for the economic survival of both city and country.

Solutions lie in viewing the world's transportation as an integrated system, in which the solutions to rural road problems are addressed not only by improvements in design, construction and management practices that relate directly to rural roads but in changes affecting the way city and intercity transportation systems are provided. Much of the help needed for local roads will have to come from remedies affecting the other parts of the global network.

Making the necessary changes in policy calls for new approaches to financing and a more effective organization of the world's transportation research and development.

In this conference technical solutions are the principal focus, but key policy issues will have to be resolved if sound engineering and management practices are to be effectively applied.

Low volume roads, although they represent 90 percent of the world's highway mileage, are losing out in the competition for attention and support. Cities and intercity routes are everywhere absorbing a major part of the resources available for transport. Yet the economic prospects of the globe depend increasingly on local roads for raising the incomes and purchasing power of the rural poor, supplying more adequate diets, providing easier access to industrial raw materials, supporting the cities and expanding the levels of world output and trade.

The ability to view the world from outer space has furthered our understanding of the transportation system and its functions. Remote-sensing satellites can detect conditions on earth with such precision that trends in transportation and related conditions are visible from space that often go unnoticed by people on the ground. The most important of these observations concern the shrinking size of the earth, the great gap in transport capabilities between the rich countries and the poor, the increasingly integrated global economy, and the growing challenge of mounting world population. Each of these conditions being highlighted by space imagery will be having a major impact on the world transportation agenda for the 1980's and beyond, and on the importance of rural roads.

A Shrinking Planet

Pictures from Apollo 11 show the small size of the earth as it appears to astronauts 100,000 miles from home. The earth has also become small for those whose travels are confined to inner space. Until very recently people could travel long distances only on the power of the wind. Not much more than 100 years ago Jules Verne could only imagine a trip Around the World in Eighty Days. In the late 1800's the sailing ship Nellie Bly finally made the journey in 72 days. But as recently as 1924 two U.S. Army planes had only cut the Nellie Bly's record time in half. Now, with the speed of jets, there is hardly a place on earth that cannot be reached in a day. And with earth-orbiting space shuttles, the time around the world has gone from eighty days to ninety minutes.

An Integrated Global Economy

A world rapidly shrinking in size has become increasingly interdependent. Today one-fourth of everything the world produces is traded across international borders. Forty percent of everything America exports goes to developing countries. World trade continues to increase twice as fast as gross world product. We have become so dependent on outside sources of supply that an American automobile consists of parts and components from 32 countries. By the time a 1983 model reaches the buyer, it has already traveled more miles that it will ever be driven.

In Tokyo more hamburgers are sold in the Ginza than at any other McDonald's in the world. In Osaka the makers of Japanese Scotch whisky have taken over control of the Encyclopaedia Britanica. On our closely integrated planet an average of 400,000 passengers a day are riding on international airlines and international telephone calls have increased from a million in 1955 to over 200 million in 1982.

The spotlight is now shifting from travel and trade to the international integration of industry. Japan makes transmissions for General Motors plants in Australia and Brazil. Europe's A-300 Airbus is assembled in Toulouse, gets its engines from the United States, is supported by wings from England, and is flown from a cockpit made in France. Ford uses parts and components from six European countries for assembly in Spain and Germany. France's Renault owns part of American Motors, General Motors owns part of

Japan's Isuzu Motors, and everywhere joint ventures have been made feasible by international transport and communications.

The Challenge of World Growth

Landsat completes fourteen trips around the earth every 24 hours. By the time it finishes its fourteenth daily orbit there are 200,000 more people in the world than there were when the day's first trip began.

The population of the Earth is expected to increase from 4.7 billion in 1983 to over 6 billion early in the 21st century. Eventually 10 billion people may have to be supported before a stationary level of population is reached.

Most of the world's growing population will be living at considerably higher levels of consumption by the year 2000 if anything like current growth rates can be maintained. It is estimated that the world economy was producing $9.5 trillion of goods and services in 1978. It took an estimated 25 trillion ton-kilometers of freight hauling to reach that level--about 2.5 ton-kilometers per dollar of gross world product. A large additional increment of freight that cannot be measured was moving on the backs of men and animals and in carts and wagons.

If gross world product in the year 2000 reaches the anticipated level of $20 trillion in 1979 dollars, this doubling of the output of goods and services will have to be supported by as much as a doubling of both freight and passenger movement.

The movement away from rural areas to the cities is increasing the importance of suppyling large quantities of materials from rural sources to city consumers. The world was 20 percent urban in 1950, it is 40 percent urban today, and by the year 2000 the planet may be 50 percent urbanized.

The production of more food will be critical. Even now one-fourth of the world's people have too little to eat, and hundreds of millions suffer from disease and infirmity resulting from malnutrition. While the world has the potential for feeding itself, it will take a marked increase in the amount of land under cultivation and multiple cropping. That will multiply the need for all-weather transportation to and from the farm. Low volume roads are the high-priority network.

The Four Transportation Systems

As we trace the traffic movements of the world over the surface of the globe it is apparent that there are four fairly distinct transportation networks.

The Intercontinental Routes

These are visible only in the wake of ocean liners and the vapor trails of jet planes. In a world 70 percent water and surrounded by air, intercontinental rights of way are supplied cost-free by nature. Modern technology permits those rights of way to be used effectively for the first time in history, which explains how we have so suddenly become one world.

The other three networks are more costly. They include the urban transport systems, the intercity networks, and a vast web of local rural roads. What is evident from space is that city and intercity systems are carrying the heaviest burdens and that rural roads are less visible and less traveled. But they are generally the only means of access to the approximately two-thirds of the world in forests, crops and pasture.

Rural Systems

Landsat spacecraft transmit an impressive picture of the part that local roads are playing in agricultural and rural development. In the United States, two and a half million farms are connected to the rest of the country by a network of roads that provides two miles for every square mile of cultivated land, 80 percent of the mileage surfaced. All-weather access means on-time delivery of seed and fertilizer and the speedy marketing of farm produce. Two million miles of local roads are the end and the beginning of the urban-rural links that can take much of the credit for high levels of productivity in agriculture and for the enormous surpluses available for export.

Local roads in the United States not only get things moved but have completely changed the way farming is organized. Many farms now specialize in doing one thing on a large scale--raising hogs, producing eggs, growing fruit or concentrating on wheat, corn and soybeans. Many farmers join with others in the same business in order to increase the benefits of large-scale operations. In the mid-west one such joint venture involves 27 farms in four different states that are producing half a million eggs a day, combining their purchases of feed and other inputs and jointly marketing their output. Reliable all-weather roads make such joint ventures feasible in spite of the wide spatial separation of the producers. In the state of Georgia chicken farmers have gotten together to make use of a central hatchery that is affiliated with a network of 200 farms and a central processing plant that dresses and packages 30,000 broilers a day. The roads are the integrating network.

Rural transportation is justified not only because it facilitates the movement of materials and crops. Much of the benefit accrues from improvements in personal mobility, including education made possible by ease of travel. American history reveals the obstacles imposed by poor transportation to education dispensed through the one-room schoolhouse. Lack of mobility made it necessary to provide instruction within walking distance of widely dispersed farm houses. But the motor bus and all-weather road made it possible after 1920 to consolidate many small schools into one larger and better school. The one-room schoolhouse with one teacher for eight grades began to disappear at the rate of 4,000 a year in the twenties and thirties. Consolidated schools, well staffed and equipped, have been a direct consequence of better local road transport, and today in the United States a third of a million buses carry 22 million students to school each day, with heavy reliance on local roads.

As Landsat speeds across the vast stretches of land in the developing world, dirt tracks and footpaths present a different picture. Lack of rural roads and their poor condition are primary reasons for low productivity, lack of trade, inadequate incomes, food deficiencies and shortages of everything needed for a better life. Often the reasons given for the poor state of agriculture is the absence of wells, the short supply of fertilizers, and the lack of technical assistance and credit facilities. But the underlying difficulty that contributes to these problems is often the lack of mobility due to bad roads, or the complete absence of any means of access to farm land and other resources. Seven out of every ten villages in India are without all-weather approach roads and thus isolated from the rest of the economy. Hundreds of millions of people in developing countries are making no contribution to the economy other than meeting their own minimal needs, and urban industries find few rural customers for the goods and services they produce.

But where roads are passable, their limited capacity is put to good use. Notable success has been achieved in India through a nationwide scheme for collecting and processing milk and dairy products. Every day 2 million producers transport their milk over local roads to collection points where trucks make their daily pick-ups for delivery to central dairies. There the milk is pasteurized and shipped to outlets in Delhi, Bombay and other cities. Supplies are collected from 10,000 villages, where even the landless poor with one or two cows can participate in the national milk cooperative.1/

A vital role has also been played by local roads in India's satellite instructional television experiment (SITE). NASA was responsible for stationing the satellite over the subcontinent, while Indian technicians turned to the task of riding the rural roads to select 2,400 villages out of India's 600,000 rural settlements that would be included in the experiment. The final choices had to be villages with road connections good enough to have electricity supplied and sufficiently reliable to get the equipment in to allow maintenance and repairmen to reach the scene when needed. Satellite television depended on advanced telecommunications technology, but local roads established the limits as to how the new technology could be applied.

Urban Systems

Less than one percent of the earth is urban, but understandably the transport networks in cities attract major funding and attention. They contain 40 percent of the world's people and most of its industrial activity. These growing concentrations have an almost insatiable appetite for additional transport capacity supplied at extremely high cost. Urban expressways, railways, buses, subways, airports, harbors and other terminal facilities have become an enormous drain on available transport funds. Intercity rail and highway connections that carry much of a nation's traffic and add to the demand for greater capacity and modernization.

Passing over Chicago, Landsat reveals what it takes to keep the metropolis moving. In this second-largest city in the United States the transportation net carries the incoming and outgoing freight of 14,000 manufacturing plants, 113,000 wholesale establishments, and 57,000 retail outlets. Total outbound freight in a single year exceeds 50 million tons. The port of Chicago accommodates 14 overseas shipping lines that move locally manufactured goods to 47 ports in 24 countries. At O'Hare International Airport, the busiest in the world, 40 million people come and go by plane during the course of a year. Two million workers have to be transported to and from their jobs every day, while a labyrinth of railroads and 300,000 trucks supply a never-ending replenishment of meats and poultry, fruits and vegetables and millions of tons of other goods to assure three meals a day for eight million people.

The concentration of people, income and automobile ownership in cities has received major outlays for urban streets, expressways, traffic control, parking and underground rapid transit. A high percentage of transportation funds are used within city limits and on intercity connections.

Intercity Systems

Along with urban transport, intercity systems have received much of the emphasis in transport development and in the modernization of facilities. Satellite pictures show clearly the lines of America's coast-to-coast Interstate Highway network, as well as the ribbons of steel that comprise its railway freight system. Europe has invested heavily in its international highway routes and Trans-Europe express trains, and the toll roads and bullet train network of Japan are sharply defined in color composites from space. While intercoastal and river transport provide low-cost movement of materials and manufactured products in many areas of the world, most of the intercity freight and passenger movements of the globe take place on road and rail facilities built and maintained at heavy cost.

The combination of facilities and services to meet the needs of the cities and the elaborate networks that carry traffic between cities have absorbed a large part of the resources and ingenuity available for transport development throughout the world. The significance of this point for rural roads is that while all four systems of transport are in reality one global network, each is separately administered and financed and competes for attention and resources. These resources, however, are limited, and rural transportation facilities that are least visible and only

1/ World Bank, World Development Report, 1982, "The Milk Revolution in India," p. 83

lightly traveled are least likely to be given the emphasis they require.

The Allocation of Resources

Every country allocates a fairly constant percentage of its national product or of its development budget to the transportation sector. In the United States about one to one and a half percent of gross national product generally goes for highways. In developing countries, the percentage of development funds allocated to transportation varies from 14 percent in Indonesia to 17 and 18 percent in Pakistan and India. While the figures vary, they are a reminder that only so much is available for transport as a whole. Local roads generally operate on the residual, after other needs are met. This is no longer a satisfactory arrangement in a world increasingly dependent on rural resources to keep the urban-industrial sectors alive.

The prosperity of the cities is closely tied to the economic fortunes of the countryside. Rural consumers are the customers for city-made products. Rural roads deliver the food and raw materials for cities. A total system view of transportation, therefore, suggests measures to bring about a better balance between outlays for transportation in city and country in order to assure the construction and maintenance of essential rural roads.

Savings in urban transport outlays are possible by applying low-cost system management techniques that make use of traffic engineering and pricing policies rather than relying exclusively on more expressways and more rapid transit. The cost of one 20-mile underground rail rapid transit line is enough to build at least 10,000 miles of rural roads.

The revenues that are collectible in the cities by charging motorists the marginal social costs of rush hour driving could help support the rural roads that are feeding the cities and providing markets for their industry. These are logical system solutions that could contribute to the effective operation of the total network.

In the cities, too, there are good prospects for raising more transportation revenues. Hong Kong is experimenting with electronic billing of motorists for their use of city streets in rush hours. This approach, now being tested with 15,000 government-owned vehicles, is made possible by vehicle identification plates and circuits in the pavement that transmit information to a central computer, identifying the vehicle and time of passage. Monthly charges will be tallied and road bills mailed monthly like electric bills.

A further means of increasing financial support for urban transportation is suggested by European experience with infrastructure banks. In Germany last year 600 savings banks chartered by local govenments have outstanding loans of $32 billion for the financing of public works. Part of the annual profits of the banks is turned over to municipal governments to subsidize infrastructure projects. Belgium finances 60 percent of all local public works through municipal banks and in Norway the combination of community banks and pension funds underwrites half of all municipal debt. New Jersey may be first in the United States to try this 100-year old European approach. 2/

Other types of solutions include guiding of metropolitan growth outward into pre-planned satellite cites located away from center city congestion. A mix of living, working and services in the satellites cuts down on costly commuting. Examples are numerous and suggest that such changes in urban form, aided by telecommunications, may be the major means of decongesting urban transport in future years. A look at the world from space shows how Stockholm, Paris, Tokyo, Osaka, Singapore and Seoul and other cities are beginning to manage their own space problems by dispersing population in pre-planned urban regions.

Projections of populations in the world's big cities by the year 2000 stress the urgency of these types of planned dispersal if the simultaneous need for financing rural parts of the transport system is to stand any chance of being met. Mexico City is expected to have a population of 31 million by the end of this century, Sao Paulo 26 million, Rio 19 million. In 1950, each of these cites had only 3 million people.

More money could be allocated to rural roads by changes in intercity transport policies. The conflicts among various methods of intercity transportation need to be resolved by intermodal systems that provide a complete service under one management. The container and the computer have accelerated the growth of integrated multi-modal networks and it should be possible to overcome much of the waste and duplication that results from each method of transportation going it alone. In the United States deregulation is leading to the creation of effective road-rail coordination and to the successful combination of air cargo and trucking services for priority shipments.

In the highway field, the high cost of intercity road systems such as America's Interstate Highways has drained funds away from other needed projects, including the maintenance and improvement of rural bridges and low-volume roads. Assurance of necessary maintenance and replacement of the Interstate System that carries 20 percent of the nation's traffic may require supplementary charges to avoid neglecting this major investment and to prevent the depreciation of lesser primary roads and bridges. Tolls are already charged on 2,000 miles of interstate highways and have been used to finance Japan's national system of expressways as well as those of Italy and Korea. Special toll charges would make it possible to allocate more motor vehicle tax revenues to local roads.

For many low-income countries, however, the cost of needed maintenance and extension of rural roads is so great that outside assistance

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2/ "Community Controlled Banks" in Transatlantic Perspectives The German Marshall Fund of the United States, May 1983, p. 13

is required for any major progress. Just as the United States relied heavily on foreign technical and financial assistance in the 19th century to help build its transport network, much of the developing world is now urgently in need of a global program to help create the basic rural systems on which an integrated global economy will be increasingly dependent.

Global Disparities

In spite of the fact that the earth has been compressed by modern transport into one world physically, it is two very different worlds economically, and this is apparent in what Landsat imagery transmits to the earth. Remote sensing reflects the fact the side of the globe with most of the people is the side with the least transportation. The roads that appear so prominently in the North are less frequently detected in the South. The United States and Europe own 80 percent of the world's motor vehicles. The Soviet Union alone accounts for half of all the world's railway freight. Half the world's airline passengers are riding on domestic flights in the United States.

At the other end of the spectrum, Africa, Asia and South America have 75 percent of the world's people and 61 percent of the area, but only 9 percent of the motor vehicles (excluding Japan) and 10 percent of the highways. A dozen countries containing half the population of the world own fewer than 2 percent of the world's motor vehicles. An outstanding characteristic of the globe visible from outer space is the inaccessibility of much of the land and therefore the resources of the planet.

Satellite pictures show how the world's road networks often dead-end beyond the major cities. At that point much of the population of the planet and much of its resource wealth remain inaccessible. In a world that has suddenly been compressed in size, prosperity may be unattainable when half the globe is immobile and stagnating. There can be no effective program of food production, job creation and income promotion if the basic transportation means are not available. To meet the rapidly growing demand for transportation in the last years of the century, it will be necessary to assure the maintenance and extension of the millions of miles of roads needed for agriculture and rural development. That calls for an international effort to improve the construction and maintenance capabilities and the management and budgeting efforts of local road administrators in Third World countries.

An International Cooperative Effort

Current programs of international financing for road transport show some basic flaws. In any given year only a few countries can be helped, and help is neither substantial nor continuing. An accelerated program and a sustained effort are needed to provide a basis for long-term plans, for building a competent road organization, and for creating the necessary maintenance capabilities. The lessons of federal aid in the United States suggest possible changes in aid for Third World countries.

The federal government initiated an aid program for getting America out of the mud that began in 1916 and has since demonstrated a number of relevant lessons. The United States did not grant aid on a project basis, but laid the groundwork for a system-wide program through annual appropriations distributed among the states on the basis of population, area and road mileage. Income per capita would certainly be an added factor in any revisions of financial aid to developing countries today.

Federal assistance in the United States was made contingent on the designation by each state of a road system comprising 7 percent of total mileage. Grants had to be matched on a 50-50 basis, design standards had to be adhered to, and maintenance of federally aided roads had to be to acceptable levels if aid were to be continued. Federal commitment to a continuing program made it possible for state highway departments to plan their construction programs with the assurance that funding would be sustained, permitting them to carry out advance land acquisition and draw up preliminary long range plans.

Developing countries willing to enter into an agreement with an international financing agency could benefit substantially from the introduction of similar programs for local roads, contingent on certain assurances. It would be necessary to establish competent roadbuilding agencies and to carry out prescribed maintenance operations. Matching provisions would have to be tailored to individual country finances, and funds would need to be granted for maintenance as well as construction. Rural roads would also need to be designated in close cooperation with agriculture departments and rural development agencies. There might also be a parallel need in some countries to assist business and public agencies or cooperatives in the purchase of farm trucks and other vehicles.

A roadbuilding program for world agriculture and rural development would benefit nearly every one: the one-half of the world living in rural poverty and in need of adequate nutrition at affordable cost; the urban industries that need rural customers; and the roadbuilding and automotive equipment industries whose major markets in the future will be in developing countries. Underwriting the program might now be possible through an automatically collected international tax on some aspect of global transport operations--a tax on international trade, on internationally traded oil, or on the value of world motor vehicle production. Funds collected would be credited to the World Bank's International Development Association. It takes neither imagery nor imagination to sense that this could be an effective long-run program to reduce rural isolation and to further the rate of global economic development.

Organizing a Global Approach

How could such a program be gotten underway? In today's world one has little trouble in finding out the conditions and trends in world agriculture, health, housing, labor, trade, environment or monetary affairs. World centers of responsibility have been established where one can gain a fairly accurate picture of how humanity is faring in a wide variety of activities, and what the needs and prospects for the future may be. Strangely, however, the transportation that has helped make possible these global approaches is itself lacking a global approach. There is no place to turn for a world view of transportation and for a reliable assessment of the volumes and types of traffic to be moved in the future. We do not know how much transport will be needed to feed a world of six billion people, to support the great urban concentrations now projected, or to support the trends in industrial production and trade.

The United States, which has so clearly demonstrated the importance of transportation to development, should take the lead, through the National Research Council and the Department of Transportation, to begin the process of establishing a global network of organizations in the transport field that would focus responsibility for extending and improving the world's transport capabilities. The American agency with primary interest is the Transportation Research Board.

The function of a global network of public and private agencies in the transport sector would include the furthering of international cooperation in the conduct of research and developemnt, in education, and in the analysis and exchange of relevant experience. A center somewhere in the network would serve as a focal point of responsibility to help assure the transportation needed to support the increasing population, urbanization and industrialization of the planet. Taking a world view of transportation would put the necessary emphasis on rural roads as the essential means of access to the resources of the globe in which all nations have a stake.

PROBLEM SOLVING DISCUSSION
3RD INTERNATIONAL CONFERENCE ON LOW VOLUME ROADS
MONDAY, JULY 25, 1983

The Monday evening session on Problem Solving was moderated by E. J. Huffington, Clark County Illinois, County Superintendent of Highways, and Melvin Larsen, Illinois Department of Transportation, Chairman of the Low Volume Roads Committee. Mr. Larsen opened the session by stating that there were more problems than solutions. The discussion of problems lead to awareness of the problem; there is a sharing of effort at solution; it leads to innovative solutions; and it points out the need for further studies. Professor Lynne Irwin of Cornell University stated earlier that we have solutions which do work but have not been communicated to others. This is called "technology transfer." The Rural Technical Assistance Program, "RTAP," is a program through which the Federal Highway Administration is attempting to accomplish technology transfer to local agencies throughout the United States.

Mr. Larsen pointed out that maintenance is a prime discussion subject yet it ranked very low in a survey by the American Road and Transportation Builders Association. This may not be unusual. It was pointed out in an editorial in the Engineering News Record in June of 1983 that maintenance is too often given very little attention. In fact, deferred maintenance seems to be the means by which we are coping with funding shortfalls today. The editorial pointed out that a major handbook on civil engineering treats the subject of maintenance under life cycle costs in three paragraphs including this commentary, "Post construction costs are permitted to be high so that initial costs can be kept within the owner's construction budget; otherwise the project will not be built. The client hopes to have sufficient capital later to pay for the higher operation and maintenance costs."

Mr. Larsen also pointed out some dichotomies such as the desire for a national set of design standards or criteria and yet a desire by local agéncies for individuality in order to comply with situations that are local in nature.

He also pointed out some of the similarities and differences of developing countries and those in the United States. For instance, the effect of local roads on economic and social aspects of a community or area is similar in both instances. However, differences lie in the fact that in developing countries very little has been done to establish badly needed roads in some areas, while in the United States there may be a need to eliminate some roads so that others may be better maintained.

He challenged the group with a query from Clark Oglesby, Professor Emeritus of Stanford University, "Is there progress being made in making people and engineers aware that low volume roads are unique compared to the rest of our highway system?"

Dr. Louis Berger, of Berger and Associates, pointed out the concern about the amount of investment that can be spent in order to receive a return from economic, agricultural and social points of view. He felt that if you determined the relevance of a road on the basis of expected returns, it would put a whole new light on the subject of roads in developing countries. He stated that low volume roads must be low cost roads as well. He stated it might be necessary to spend as little as $200 per kilometer for a road carrying five vehicles per day. He expressed the opinion that our experience with county roads is far more relevant to developing countries than our expertise in building modern superhighways.

Mr. Madonia, of Illinois, asked whether certain roads could receive less maintenance than others by designating these roads as primitive roads. Mr. Schornhorst, of Iowa, pointed out that Iowa has a law which permits a county board of supervisors to provide two levels of service which might relate to the primitive road mentioned. The board may designate which roads are to be maintained at the higher or lower level and may set the standards for the lower level. There is reluctance to employ this approach for safety reasons. Although low volume county roads are built and maintained for the use of local residents who may not find a lower level of maintenance troublesome, even the most lightly traveled road will occasionally be used by strangers. Alcohol is also a problem. Any road hazard is magnified by the intoxicated driver. The issue of county liability in accidents on such "primitive" roads has not been tested.

Further reluctance stems from possible adverse public reaction to an intentional effort on the part of a county board of supervisors to lower maintenance standards.

It was also brought out that road density and level of maintenance depends greatly upon the productivity of the land. In Montana, for instance, there may be a road for 3,000 or 4,000 acres whereas in Illinois there is a road for perhaps 300 acres. Also there is the problem of urban dwellers who like the rural life but then demand services which are beyond those that can be provided within the economics available in rural areas.

Mr. Pelzner, of the Forest Service, pointed out that our roads are becoming multi-purpose roads. He described roads which are made essentially for the purpose of moving timber out of the National Forests; these roads are being built as a part of the sale of that timber. This approach might be used in the development of oil, coal and agriculture as a means of providing financing for such roads.

In the USA, the dispersal of urban populations to the hinterland has put pressure on the rural low volume roads. In developing countries there is a greater need to develop rural transportation networks. Otherwise people in rural areas will migrate to the cities which then become overcrowded, with increased social and economic problems for the Nation. If there were a concentration on rural transportation then we could hopefully eliminate some of the social and economic ills which are associated with crowded urban areas as well as neglected rural areas. In addition, the development of highways stimulates the development of the rural areas which become productive assets rather than just liabilities. Wilfred Owen, of Brookings Institution, mentioned in his opening remarks that roads provide social amenities to rural areas. Transportation provides ways of correcting social ills and reducing spending on social programs.

Mr. Ring, of the FHWA, questioned whether studies have been done on the effect of the improvement of roads on the economy of the area. It was pointed out that, at least in the U.S., there is a higher tax rate if the land has good access. With improved access, the sale price of the land increases which effects the taxable valuation of the land.

Just keeping the road in sufficient repair to keep it as a road is one of the biggest problems in developing countries. One of the main problems is finding funds that will be used in the future for these roads. They depend upon aid from other agencies for construction. They sometimes depend upon a private system of highways built by private investment.

It was pointed out that not only do we need low cost but low standards where there are no roads. Peter Thompson of South Africa mentioned that communities without any roads would be helped very much by a low standard highway. The main requirement for a road such as that is that it is well drained. He suggested that we put a maxmium on the standard that would be built rather than a minimum. He recommended the use of stage construction recognizing that there will be weak points in these highways which can be improved over time rather than building a road that will not need any maintenance in the future.

The consensus was that the papers at this conference were much more specifically oriented toward low volume roads than the Second International Conference in Ames, Iowa. Dr. Mathew Betz, of Arizona State University, pointed out that the discussion on problem solving had dealt more with the appropriateness of situations to low volume roads and the land that they serve than it had at previous discussions and conferences. Mr. Huffington pointed out that if this was so we need to take it on ourselves not only to be good engineers but also good salesmen and let our legislators know of the need for keeping the rural roads in the condition that will keep this country vital.

Mr. Larsen summed up the session by stating that just as in developing countries, there is a lack of funds in the U.S. and this is measured by what we have had in the past. It appears that we will need to go back to basics and ingenuity to solve some of our problems. There must be a recognition that in the developing world as well as in the United States there are great opportunities for seeing that transportation can and will affect the social and economic welfare of great groups of people. It was emphasized that our county engineers are ingenious in providing low cost roads and they have become very adept at keeping the criteria appropriate for the type of road that is needed as well as keeping the quality at a level that can be justified.

FINDINGS OF THE SPECIAL PANEL ON RESEARCH

Introduction

A major task completed at the Third International Conference on Low Volume Roads was the identification of those facets of low volume road engineering and management where additional research would yield major benefits. To accomplish this goal, a special task group of 35 engineers, officials and researchers met during the conference. The aim of this group was not a simple discussion of research needs, although such discussions were conducted. The real objective was to delineate those areas where commonality of need and interest would maximize the ultimate benefits of research.

The task group was led in its discussion by Sam Silberman of the Arizona Department of Transportation, aided by Dr. Mathew Betz of Arizona State University. The membership of the task group was evenly split between those whose primary concern was the maintenance and development of low volume roads outside the United States and those principally concerned with local roads within the United States. There were several participants whose interest could truly be described as global. A roster of the task group is appended.

Method

To achieve the stated goal, the task group moved from the specific to the general. The first order of business was to assemble a list of specific research needs statements. Such statements, proposed by task group members, cited specific problems whose solutions might be derived from research. Seventy-four specific needs statements were proposed.

These statements were discussed and any bases of commonality among statements were identified. By this process, "topic areas" where research was needed were identified. In some cases five or six of the specific statements might belong to a common area. In other cases, the specific statement might address a problem so unique that no direct relationship to other problems could be discerned. It must be realized that this uniqueness is relative only to the other research needs identified and not to the significance or insignificance of the specific problem. For example, the need to develop a synthesis of case law relative to low volume roads managment was a specific need statement that was judged significant enough to be a "topic area."

Once the areas of needed research were identified, the task group members were asked to assess those topics where research is likely to yield the greatest benefits.

Polls were conducted in four separate categories. The categories were:

1. economic and/or administrative topics globally significant.
2. technological topics globally important.
3. topics important to local jurisdicitions in the U.S.
4. topics important to state and federal jurisdictions in the U.S.

Although categories one and two indicate global importance, the vast majority of the topics and the discussions concerned the role of low volume roads in economically developing countries, many of which are expanding their transport infrastructure. The inclusion of category four reflects the fact that many states administer low volume roads systems and that the U.S. Department of Agriculture and Interior as well as other federal agencies administer still larger low volume road systems.

Results

Table 1, on page 11, indicates the ranking and identification of those topics which were voted to be most important by the participants.

It is significant, comparing the differences in categories and the fact that over 30 topic areas were considered, that less than 12 individual topic areas appear in the rankings. In light of the diversity of the participants' backgrounds, interest, and responsibilities, this result would lead one to believe that the major research agenda for low volume roads transcends geographic or economic boundaries. Even more startling may be the fact that the top three ranked subjects in three of the categories are exactly the same. In at least one of the categories these three far outranked the fourth-ranked issue.

The evidence of non-jurisdictional bias is also reflected in the technical subjects reviewed in that those areas of most concern to the local jurisdictions within the United States include one technical problem of concern globally, and those issues identified as of state or federal interest include not only the top three ranked economic and administrative factors, but also the third and fifth-ranked technical problems of global concern.

Summary

The repetition among these lists of topics is striking.

The need to create better systems of information exchange was cited in each category. This is more than the fear that every educated man or woman has of ignorance. Low volume road engineers and administrators most often practice their crafts far removed from research and training institutions. Without mechanisms of information exchange that actively seek out these individuals, they will continue to feel isolated from progress. Conversely, their colleagues and the engineering community at large will remain ignorant of the experience and needs of this dedicated group.

As indicated in Wilfred Owen's Conference Keynote Address, local low volume roads are the least visible of the world's major transportation networks. "Local roads generally operate on the residual, after other needs are met." Low volume roads administrators throughout the world agree with Dr. Owen that "this is no longer a satisfactory arrangement." Hence, the common assessment, both globally and domestically in the U.S., that new sources of funds must be identified, and, innovative funding and allocation methods must be developed.

Correlative to funding problems is the general consensus that program management systems must be developed that will maximize the benefits of available funding. It is most important that such systems are specific to low volume roads and are not simply downsized versions of programs applicable to urban and intercity expressways and other high volume networks.

The repeated need for more research on marginal or nonstandard materials and the development of "risk analysis" alternative design concepts that allow for the incorporation of marginal material on a rational basis also reflect, in part, the scarce funding given to low volume roads. These topics also are a reminder that the "common" construction materials of North America and Western Europe are not necessarily common elsewhere and that the empirically derived standards for construction used in North America and Europe may not apply to materials in different geologic and climatic environments.

The interrelationship of user costs and alternative designs was cited as both a global and American domestic topic for research. This was echoed in Dr. Clarkson Oglesby's summary address. Dr. Oglesby offered the opinion that practical user cost data are essential to demonstrate the actual value of design options and to demonstrate the true impact of underfunding to legislative bodies or other funding agencies.

A major topic of "classical" technical research cited both in the global technical category and the U.S. state and federal category is the study of damage mechanisms in low volume roads. The mechanisms by which earthen, aggregate or lightly surfaced roads deteriorate under traffic and/or environmental conditions are not well understood. Indeed, there seems to be no consensus definition of "failure." Only a thorough understanding of the mechanisms of deterioration in the light of the special traffic, materials and design considerations of low volume roads, will enable engineers to effectively combat the problem.

One topic appropriately had greater significance globally than to the United States. This was research into the cause and effect relationship of physical accessibility and social and economic developments. We still have little rational information on the ability of roads to promote development. This necessarily hinders the decision-making process for low volume roads administrators.

In the U.S. there is a heightened awareness of the legal aspects of low volume roads administration. This awareness is most keenly felt at the local level and a need to synthesize a legal "casebook" for the use of local engineers and managers is now necessary.

In all, the task group identified 11 topic areas where research and development efforts can produce major benefits for the engineering and administration of low volume roads. The enumeration of these topic areas or goals is, however, only the first, and easiest, step toward the reaping of those benefits. Now that these goals have been clearly established, TRB and other transportation and research agencies must develop concrete proposals for research and development projects aimed at their achievement. Funding for actual conduct of such research must be generated and prompt and extensive reporting of research results must be undertaken.

Table 1. Low Volume Roads Research Needs

Rank	Global Economic and Administrative Topics	Global Technical Topics	Local Jurisdications U.S.A.	State and Federal U.S.A.
1st	A	D	A	B
2nd	B	H	B	A
3rd	C	I	C	C
4th	F	A	D	I
5th	G	E	J	E & K

A -- The development of more effective methods to correlate and disseminate information and the results of previous research.

B -- The development of program management systems in design, maintenance, and construction, which will maximize the benefits of available funding and utilize standards appropriate to low volume roads.

C -- Development of innovative funding mechanisms. This includes identification of new funding sources and research into equitable distribution of funding responsibilities.

D -- Research into the characteristics of marginal, substandard, and unconventional materials and development of guidelines for selection and standards for their use.

E -- Development of greater understanding of the mechanisms of damage to low volume roads. This includes both traffic and environmental damage. Problems associated with heavy loads were cited, as well as damage due to unique traffic found on low volume roads, such as damage caused by hardened steel horseshoes.

F -- Research into the measurement of the cause-and-effect relationship among physical accessibility (roads) and economic and social development, including the effect of road construction, or lack of it, on population migration patterns.

G -- Continued development of methods to utilize user cost predictions in the analysis of alternative designs for low volume roads. This includes the need to correlate data generated by different user cost models currently in use.

Table 1. cont'd.

H -- The need for improved maintenance/management techniques that are flexible enough to be adapted to specific low volume road situations. This should incorporate risk analysis in maintenance determination and should recognize the special, and radically differing, traffic characteristics of low volume roads.

I -- Development of risk-based design concepts that recognize the problems of materials quality and availability. Although similar to Item D, this topic calls for the development of rational design methods that use such materials.

J -- The development of a national case law synthesis for managers of low volume road systems. This synthesis should deal with tort liability and the legal ramifications of engineering decisions related to low volume roads.

K -- Development of guidelines for the acceptance of alternative designs and methodologies and to assess the impacts of such alternate designs on user costs as well as capital costs.

APPENDIX A - SPECIFIC RESEARCH TOPICS SUGGESTED BY THE PANEL

1. Adopt electronic equipment to measure, monitor and characterize low volume road traffic.
2. Improve traffic flow estimation and traffic characterization techniques.
3. Identify innovative funding sources and methods.
4. Research into use of unconventional or substandard materials.
5. Develop low volume road specific traffic safety engineering criteria.
6. Improve methods of information exchange.
7. Develop methods to analyze the economics of alternative design and maintenance standards.
8. Develop new approaches to remedial drainage works for low volume roads.
9. Improve the organizational efficiency of existing highway agencies.
10. Define low volume roads in terms of function and special requirements.
11. Improve low volume roadway design to optimize the use of corridor by broadly mixed traffic types.
12. Develop unified rapid methods for stabilization mix design.
13 Develop a method to evaluate base course performance using observed field strengths.
14. Develop new maintenance standards that reflect the possible as well as desirable level of achievement.
15. Develop environmental protection standards for sensitive areas.
16. Develop applications of small computers to design problems at the field level.
17. Risk based design methods that utilize material variability and availability concepts.
18. Identify lower cost alternatives to asphalt surfacing.
19. Develop a synthesis of case law relative to management of low volume road systems.
20. Develop methods to measure the relationship between socioeconomic development and physical accessibility.
21. Develop better methods to manage the allocation of funds throughout low volume road networks.
22. Design equipment modifications for multiple uses.
23. Develop training methods, manuals and other aids for non-professional personnel.
24. Develop low cost drainage structures.
25. Develop procedures for identifying natural materials sources with inexpensive aerial photography.
26. Develop a greater understanding of roadway damage and mechanisms.
27. Develop rapid, non-destructive, structural testing techniques for unpaved roads.
28. Develop procedures that use vehicle operating costs to support levels of financing.
29. Improve or develop standards for the use of local materials and labor resources.
30. Optimize methods for field control of construction and maintenance costs.
31. Define parameters influencing loss of surface aggregate.

APPENDIX B - MEMBERSHIP OF SPECIAL PANEL

Golam Ahkter
Sheladia Associates, Inc.

Victor C. Barber
U.S. Army Corps of Engineers
Waterways Experiment Station

Mathew J. Betz
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Everett C. Carter
University of Maryland

Allan M. Clayton
University of Manitoba

Baden Clegg
University of Western Australia

Gerald T. Coghlan
USDA Forest Service

Santiago Corro
National University of Mexico

Ronald W. Eck
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Asif Faiz
World Bank

Raymond J. Franklin
Federal Highway Administration

Henry Grace
Henry Grace and Partners

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Peter Long
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Raymond K. Moore
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Harold E. Myers
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Clarkson H. Oglesby
Stanford University

Adrian Pelzner
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Cesar A. V. Queiroz
Brazilian Road Research Institute

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Eugene L. Skok, Jr.
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Mumtaz A. Usmen
West Virginia University

SUMMARY ADDRESS: A DOMESTIC VIEW

Dr. Clarkson Oglesby, Stanford University

When I asked what I was supposed to do in these closing remarks, I was told to give you my personal impressions of the conference. That is what I am going to do. I realize that what I will say will reflect my personal biases, and I hope you will understand.

For me, this conference has been a tremendous learning experience, both technically and in talking to people. It was a pleasure to feel the high level of enthusiasm that everyone here had in talking about and learning about low-volume road problems. I hope we can keep it when we go back home and get buried in all the things that are waiting for us there. Also, I was personally pleased to find a strong level of agreement in this group on the fact that low-volume roads are different. Fifteen years ago that would not have been the case even among individuals who were dealing with low-volume roads. Today we accept that concept, although there are many other highway people who do not buy the notion that low volume roads are different and therefore need special attention.

In looking at the conference activities, I found them to deal with five distinct activities, three of which fall under my assignment. These three were:

1. Lessons we in the developed world must learn about and can learn from the developing world.
2. An assessment of the subjects covered by the formal papers.
3. The problems bugging low-volume road people in the United States and the need for research to aid in solving those problems.

I first want to go over very quickly what I learned about and from the people representing the developing nations. Among the lessons are:

1. Most of the population is in that part of the world, a fact that most of us have not faced up to. These people have expectations and needs and we on the small side had better be on notice.
2. The changes in the developing nations are taking place very fast. They are moving rapidly from transporting goods on human heads to trucks and moving people by walking, pedicabs, and bicycles to buses and private automobiles.
3. Progress in transportation in those nations comes through enlisting the people and getting them involved in providing the things they feel they need rather than expecting them to accept something someone else says they need. This concept should be helpful to us. Too often, we in the USA say "We're the engineers, we know what you need." This

view often is the root cause of some of our problems.
4. Data are available on vehicle operating costs that we in the United States badly need. I've been asking, "When are we going to get them in usable form." In particular, we need data on the effects of road roughness on operating costs since this is a major consideration in low-volume road situations.
5. The people concerned with roads in developing countries made clear to us that low-volume and low-cost have to go together. Somehow we in the United States have not recognized this fact in deciding such issues as geometric standards and surfacing types.

I will not attempt to discuss individually any of the 53 formal papers given at the conference. My concern is with the balance among topics. Sixty percent of the papers had to do with materials for or design of surfacings. This contrasts with about 30 percent at the first conference in Boise eight years ago. My concern is that such topics as economics, planning, design standards, or drainage received almost no attention directly. There was nothing at all on training. And yet, if you look at the list of important issues developed at the session on research needs, as reported earlier in this session by Mathew Betz, these issues are the ones at the top. And so, in appraising the conference papers from a national point of view I must ask, "Are we on the right track in our research emphasis?" Not that the papers were not excellent and the subject matter important; they were. But how do we get research going in these other areas?

A partial answer to my question may be that some of these topics were treated in detail in the excellent series of compendiums and syntheses that were financed by AID and published by TRB under the general heading of Transportation Technology Support for Developing Countries. There is a vast sum of knowledge in them. To my astonishment, I discovered that many people at the conference did not know they existed?

Another topic that received almost no attention at the conference was safety. The people who were running scared about this omission were concerned because of the mounting costs of agency and personal liability. I see two reasons that this conference largely ignored the subject. First, safety is a universal subject and safety concepts are not unique to low-volume roads; and are treated in detail elsewhere. Second, from an economic point of view, accidents have not been a major concern with low-volume roads in developed countries. But when I looked at the slides from some of the developing countries and saw the conflicts and accident potential when pedestrians, bicycles, animal-drawn vehicles, automobiles, buses, and trucks all try to use the same roadway, I began to realize that they have a safety problem. But, repeating, I do not see it as high-priority research topic, peculiar to low-volume roads in the United States or other developed countries.

The third area which I wish to summarize stems from the conversations that took place in the lobby about problems facing people in the United States, mainly the county engineers. These concerns are reflected not in the conference papers but in the discussion of research needs. They dealt mainly with four topics, namely: communications, computers as a management tool, finance, and liability for accidents. All of these offer tremendous potential for research and reports of practice. I hope all of them will be major topics at the next low-volume roads conference.

Regarding finance, the first comment was always, "We in low-volume roads get what is left after everybody else has had his cut at the money." I would propose that this is a defeatist attitude and doesn't get us anywhere. There were helpful informal discussions of how to get money in different ways than from the state capitols and the federal government. They stressed contributions from or assessments against those who benefited. In some cases property owners might pay for the work directly. This is why it is important that we get the vehicle-operating costs data that have been developed in Kenya, Brazil, and the Caribbean into usable form. With that information, local officials could go to people and say, "If you have a rough, substandard road it is costing you this much money out of your pockets." We've never been in a position to do that before. So I am really excited that out of this conference will come reliable, factual data that can be used to get legislators and property-owner's attention.

The final item is the matter of agency and individual liability for accidents. This has gotten completely out of hand. These lawsuits and the large awards rest on the notion that road agencies and their staffs were negligent in design, maintenance, and traffic control. What we are going to have to do to handle this problem is to demonstrate that agencies and their professionals followed good, sound engineering and professional practices. To date we as engineers have left it to the lawyers to handle these lawsuits and to fight these claims. Where research and information exchange comes in is that engineers have to develop agreed-upon standards and practices (in our case for low-volume roads) and be aggressive in promoting legislation and participating in legal actions that will make these standards acceptable. This will take away the basis on which lawsuits are filed. Getting liability claims under control is one of the most pressing problems facing professionals in the United States and that is why I am pushing it so hard.

Summing up, in the four areas of communications, computers, finance, and liability, research and information exchange are important but have been neglected. We as engineers must get involved. It is not enough to build good roads. As professionals we must reach out into these areas and take them on as another professional obligation. To do this, we first must develop data and that is where research comes in.

I hope you will pardon the fact that this summary has pointed to the future, rather than dwelling entirely on the conference. I feel strongly that research on low volume roads must add these new dimensions. The technical side is being well cared for as has been clearly demonstrated by the presentations of this conference. But to me, taking a national point of view, the conference's main lesson was that we must broaden our efforts and tackle the other pressing issues which low volume road engineers must face in the years ahead.

SUMMARY ADDRESS: AN INTERNATIONAL VIEW

Victor Mahbub Mata, Secretariat of Communication and Transport
Federal Government of Mexico

Introduction

I wish to express my sincere congratulations to each and every one of the commentators of this conference. The seriousness and professional character of their work are worthy of acknowledgment and demonstrate the existing interest and concern regarding the central theme we are dealing with: Low Volume Roads. I likewise wish to express my sincere thanks to the organizers of this important event for having considered that the point of view of a country like Mexico, whose experience with low volume roads lies within a socioeconomic context different from that of the host country, would be interesting enough to be included in the closing summaries of this conference.

Having listened to most of the papers given during this conference and having carefully read the rest of the works presented, I would like to submit for all the attendees' consideration a synthesis of the points that from the so-called international view I consider to be of major importance, as well as some remarks, a very few, based on Mexican experiences with low volume roads. With this aim, I have considered it appropriate to group the different subjects we are dealing with under the following main headings: Planning, Design and Construction, Maintenance, and Pavements and Soil Mechanics.

Planning

From the keynote speech through most of the papers, it has been clearly stated that there is a significant interest in dealing with the severe restrictions that the worldwide financial crisis imposes on resource allocation for construction and maintenance of roads. This is, therefore, the time to find imaginative solutions for using limited resources inside a multiple objective framework, intelligently expressed by Mr. Owen when he stated that the world need for additional supplies, further requirements for transportation, rural access, and future social needs remain to be satisified. We live in a challenging time full of new opportunities, and this is precisely what has been shown in this conference by analyzing critical issues that must be overcome in the coming years by the road organizations of developed and developing nations.

Praiseworthy indeed are the efforts to deal with the scarcity of financial resources, which will continue to be among the main worries in the coming years, and to search for more economical and lasting materials for the construction and maintenance of low volume roads. In spite of this perplexity, however, I must point out that the human concern has been considered in many papers. For instance, it has been recommended that local transportation patterns strictly associated with tradition and the culture of diverse communites be retained. Riverson, Hine, and Kwakye have stated that the social impact of low volume roads is even more important than production increases. Nevertheless, I have to point out here that it is also important, very important, to open more agricultural areas so that their products can be traded, giving the opportunity to isolated communities to participate in the national marketing process, thus transforming it from an autonomous economy into a community with perspective.

I have listened with particular interest to the development of models which, without any doubt, will become significant planning tools for low volume roads. The efforts to find out how to invest, as well as those related to vehicle operations costs, will certainly form a technical basis for decision making. However, it must be emphasized that the value of these models stems from their use as a part of a major system. This system is the whole decision making process. In addition to the technical point of view provided by these models, one must consider, for instance, social costs, political problems, lack of technical data in many developing countries and the so-called opportunity costs. As a reinforcement to this idea, I will make reference to the vehicle operating costs that were discussed in different sessions. The papers related to this topic are mainly oriented toward reducing vehicle operating costs through improved road surface standards, such as roughness and geometry. I am convinced that a sacrifice of vehicle operating costs can be made on behalf of social costs. Let me give you a further explanation. It is important for some countries to have more roads with medium standards than to have just a few roads with higher standards. The result is that you divert cost from the people who have nothing (the inhabitants of isolated communities) to the people who have (the car owners). This is an experience that has been confirmed by more than 80,000 kilometers of these roads in my country, Mexico.

Many ingenious ideas for solving specific planning problems have been expressed in this conference. Nevertheless, the evaluation of their future use is highly recommended because problems differ from one environment to another depending on diverse characteristics and the development level for each country. For instance, Mr. Mercier's paper has a proposal related to closing a road when there are not enough resources to maintain it, thus avoiding further deterioration. This proposal might seem acceptable from a rich country's point of view. However, for a developing country with a road network in its first stages of formation, this solution might not be so well accepted since many times low volume roads are the only means of transportation.

Design and Construction

The papers presented concerning the general problems represented by the construction of low volume roads are of great importance. The experiences and analytical models on which these papers are based constitute very interesting studies which respond to the restless concern for greater knowledge of the behavior of materials and of the different elements which make up the structure of this type of road.

Sometimes, low volume roads are defined by using the annual average daily traffic of vehicles, in both directions. From the papers presented here on this subject, it seems advisable to emphasize that this single criterion can be confusing because of the large differences that may exist in the specifications and method of construction for low volume roads. Among other factors these differences depend on the degree of economic development of each country; on the policies of maintenance, rehabilitation, and construction; and on the type and composition of the traffic forecast. Concern about these differences has been expressed here by some of the authors. Because of the foregoing, it might be advisable to set up an international classification for low volume roads, with different categories, taking into account more factors, than just the volume of traffic.

Some of the papers presented, referring to construction procedures, acquaint us with the experience of new technologies based on the use of materials not previously taken advantage of on a large scale. Such is the case of rubber asphalt mentioned by Mr. Schnormeier in his qualitative and economic study. The use of this procedure has found interest in Mexico because of satisfactory experiences using it in pavements over clay soils subject to volumetric changes, notably diminishing the cracks in asphaltic surface mixtures.

The studies of stabilization and functioning of the sand bases treated with asphalt and foamed asphalt presented, one by Acott and Myburgh, and the other by Skok, Mathur, Wenck and Ramsey, offer a great possibility for the use of these materials, which have a low acquisition cost, in all countries that have a road network located in desert or coastal zones.

In the Second International Conference on Low Volume Roads Professor Miles S. Kersten mentioned that information for design of low water crossing structures is almost nonexistent.

The paper of Mr. Wen Shen shows, on the basis of inquiries, more important tangible factors, as well as the conditions that were found to be ideal for building low water crossing structures. It is important to consider that the hydraulics studies made for this purpose must include a deep concern about scour.

The physical observation of the constructed works (preferably with observations for more than 5 years), their classification by type of soil, rain precipitation, materials used in their construction, and costs of maintenance could lead to providing more data on the proper selection on this type of construction, as Mr. Eriksson pointed out in his paper.

We cite the experience of Mexico where a great number of low water crossings and bridges have already been built (mainly in the desert zones in the north of the country). There are structures older than 15 years that continue to function correctly with a minimum investment in maintenance.

For countries that are in the road network construction stage, the paper presented by Mr. Baumel on rural bridges and roads built in the United States, will be interesting. These bridges and roads face serious problems because of deterioration since the majority were built before 1940 and are now subject to very different traffic conditions. In developing countries this experience must be taken into account very carefully because traffic volume and vehicle weight may become greater. There is a concern that the constant search for lower costs will lead to a reduction of project standards.

The developing countries confront the problem of rural communication with scarce resources and are searching for the best use of local materials. Thus, they are implementing technologies with intensive labor use. Sometimes this is apparently at a higher cost than the use of imported machinery, but it creates employment and saves foreign exchange.

Maintenance

Significantly important was the observed interest that all countries, more than ever, have shown in maintenance. The proposal of Roberts and Robinson must be taken seriously. Improving management methods, reshaping budgetary policies, legislating vehicular load, and the using adequate technology and labor are realistic alternatives to the traditional strategy of increasing budgets, mainly because maintenance costs have already reached unprecedented levels.

For instance, it has been proposed to divert budgets traditionally assigned to new roads to maintenance thus reversing the common budgetary policy. The reason for this is that maintenance represents a very important contribution to the economic health of a country.

Special mention must be made of those efforts oriented to developing an adequate technology for low volume roads. What I am seeking to point out are the innovative ideas worked out to eliminate the inconvenient practice of giving low volume roads the same technical treatment as highways and freeways. There are papers that provide a technical basis for evaluating deterioration like that realized in Brazil and Idaho. There are also other papers that must be mentioned that are related to this subject, for example the work for Mr. Smith dealing with specific signalization system for low volume roads. However, I must again emphasize the fact that mathematical models must be validated for different conditions. This is especially discussed in the Brazil paper.

Pavements and Soils Mechanics

The papers presented in this conference provide an excellent summary of current problems faced in pavement construction, maintenance, and rehabilitation.

Luhr and McCullough discussed the economic evaluation of pavement design alternatives through several specific examples, using the pavement design and management system (PDMS) program, which optimizes pavement design and rehabilitation strategies on the basis of total overall cost. Perhaps, it would be appropriate to add that the potential users of these valuable techniques should recognize the importance of supplying sound and comprehensive information concerning material properties and costs, seasonal conditions, traffic, and road geometry.

Another paper related to the previous one was presented by Luhr, McCullough, and Pelzner. It described a simplified pavement design procedure for low volume roads that is based on the use of linear elastic-layer theory and performance data from the American Association of State Highway Officials (AASHO) Road Test. The elastic-modulus values used in this design procedure can be determined either by resilient-modulus testing or by either of two empirical correlations. This method is currently used by the U.S. Forest Service, and the information obtained through its implementation will be very useful to other countries. In addition to these experiences, it would be appropriate to validate this method, whose basic algorithm takes into account the environment and pavements tested in Ottawa, Illinois, utilizing studies under different conditions, such as those prevailing in tropical countries.

Coghlan presented a paper where a comparison is made of two models for pavement design: the W.E.S. model for thickness requirements for unsurfaced roads and airfields and the AASHTO model for flexible pavements with a bituminous surface course. Through some conversions the author compares both models using the same parameters as those of the AASHTO model and concludes that the W.E.S. model indicates a required pavement strength 10-50 percent lower than that developed by AASHTO for the same traffic and subgrade strength. The limitations of the W.E.S. model are indicated by the author. It is interesting to observe the large differences between the two procedures.

As Queiroz and Hudson indicated in their paper, the primary objective of their study was to develop models to predict pavement performance and behavior for Brazilian pavements. The models are needed to relate road user costs and road maintenance costs to roadway conditions in order to predict total highway transportation costs. The authors clearly indicate that rutting was found to be light in the study area (average of 2.5 mm) and probably did not act as a trigger to initiate maintenance on the pavements studied; therefore, to extend the results to other conditions, it seems desirable to carry out experimentation on other types of roads, under similar climatic conditions, in order to include information on those cases where permanent deformation becomes a significant factor in the distress mechanism.

Visser, Maree, and Marais presented a very interesting and well documented paper on the implications of light bituminous surface treatments on gravel roads. The use of dust palliatives and surface seals on gravel roads was investigated in order to find a method of upgrading their serviceability that would not require an extensive capital outlay. Regarding this paper, it can be said that the performance and design philosophy of light pavements have a great resemblance to the findings of the long-term research program carried out in Mexico where, in a dry climate, very light structures have satisfactorily endured more than one million standard axle loads over a life span of 14 years. Also, it is considered that the heavy vehicle simulator is a valuable tool for studying pavement performance in the field.

Thurmann-Moe and Ruistven presented an interesting paper on graded gravel seal (otta surfacing). It is felt that the techniques described in the paper may have great appeal in developing countries like Mexico where thin surfacings are widely used.

Scherocman presented a paper covering cold in-place recycling of low volume roads. As indicated before, this procedure has been carried out in developing countries using various types of equipment. The social and economic impact of the use of foreign technology should be analyzed carefully in each case.

Two papers were presented that show construction procedures and long-term performance of low volume roads and streets. The first, by Spelman, discusses problems on rural cold recycling in two eastern national parks; and the second, by Schnormeier, presents the use of asphalt-rubber on low-cost streets in the City of Phoenix.

Various papers were presented on asphalt stabilization. Because of space limitations only three of them will be referred to. Mamlouk and Wood dealt with the use of properties of emulsified asphalt mixtures; Castedo and Wood discussed stabilization with foamed asphalt of commonly used aggregates; finally Tia and Wood presented a paper on the use of asphalt emulsion and foamed asphalt in cold-recycled paving mixtures. It is suggested that the conclusions of this type of study be validated, or broadened, into actual projects that analyze the long-term performance of pavement structures. Most of the findings might also be applicable to higher traffic levels, at least in developing countries.

Stabilized bases could also be useful in low volume road construction. Four papers were presented covering this subject. Shah, George, and Rao showed how poor quality materials can be used when adequate stabilizers are added; bitumen, lime, cement, and even clay have been used. The paper by Ali and Youssef dealt with this aspect as applied to silt stabilization; however, it is not well understood why mechanical stabilization was disregarded. The article by Ruenkrairergsa presented a cost comparison between bases constituted of soil-cement and of crushed rock. This purely economic aspect is of great interest in countries where very few sources of economically obtainable rock exist. Finally, Usmen, Head, and Moulton presented several cases, with pertinent references, where wastes associated with coal mining have been used in low volume roads and in highways. As the authors claim, economic feasibility is probably the most important consideration that will govern their widespread use. It can be said, as a generalization of this idea, that wastes from the mining industry could also be used in low volume roads. In all cases, the common interest is the best use of available resources during construction.

The interest in predicting or determining the stress-strain characteristics of the different layers of materials of a pavement was well demonstrated by several papers presented to this conference. In the following paragraphs, reference will be made to three articles dealing with this aspect.

Visser, Queiroz, and Hudson showed the results of an interesting research program carried out in Brazil and extended with data collected by a consulting firm. Excellent laboratory work was carried out. The paper presents two models relating the resilient modulus of undisturbed samples, first with Atterberg limits and then with density and California bearing ratio (CBR); deviator stress is also taken into consideration. Unfortunately, no data are presented on the strength of the samples tested, nor is there a discussion of how the results should be applied to a practical design. It would be of interest to see how the use of a resilient modulus is implemented in design methods for pavements of low volume roads in developing countries.

The paper presented by Van Wyk, Yoder, and Wood shows the results of an investigation carried out to determine the structural equivalence factors of recycled layers. The measurements made on an experimental road, 15-km long, during a 250-day period are described. The Bistro program was used to select cross sections that gave the same dynaflect deflection basis. Structural coefficients were calculated using either the subgrade deformation or the tensile strain at the bottom of the recycled layer as the controlling criterion. It is interesting to see that the tensile strain criterion gave the smaller structural coefficients. However, it is unfortunate that the recommended structural coefficient (A_Z) for the recycled layer varies over a wide range. Anyhow, it is well known that structural coefficient values are a function of many factors as well as the failure criteria used, as concluded in this paper.

Clegg showed the application of an impact test to field evaluation of marginal base course materials. He presented interesting correlations between the results of the impact test (CIV), the California bearing ratio and a pseudo elastic model. It is suggested as a procedure for field design; however, it is emphasized that the proposal is in the development stage. The ease with which this type of test can be performed will surely be of great help both during and after construction of roads.

Fingalson and Jackura, and Hannon and Forsyth, presented two papers about the behavior of native earth structures. Here, reference is made to the first paper, where two projects are described for embankment stabilization over unstable, boggy ground with peat thickness up to 12 feet. The use of woven polypropylene filter fabric was successful and resulted in savings over conventional muck excavation. It is unfortunate that no report was made of the actual settlements and of the real volume of fill placed so that comparisons could be made with the volume that would have been placed if no fabric were used. The author reports that compaction in areas where the fabric was used was excellent. Projects like these will be common in several countries, Mexico among them, that are now investing in roads in coastal zones. However, the thicknesses of soft soil may be greater than those reported by the author.

To complement this summary of aspects related to soil mechanics and pavement design, it is appropriate to indicate that a long-term research program on the design, construction, maintenance, rehabilitation, and operation of typical roads is being carried out in Mexico. The roads studied in the program, launched by the Ministry of Communications and Transport in 1962, range from low volume paved roads to heavy traffic highways. The program covers several related areas: (a) investigation of the behavior of specially constructed test roads; (b) study of the behavior of roads representative of the national system; and (c) full-scale laboratory studies using a circular test track, test pits, and dynamic testing equipment. A design method has been developed and validated for pavements with thin surface courses and granular bases and subbases. Performance of pavements at high temperatures is one of the current research programs, as well as the study of local materials and mix design methods related to their actual performance in the field. Information on these studies has been presented to the Permanent International Association of Road Congresses (PIARC) and elsewhere.

Mr. Chairman, ladies and gentlemen. The excellent and exquisite exposition by Professor Owen in the keynote speech showed us clearly the importance of the rural, low volume roads network. It also shows us the role that we, the representatives of the people involved in construction of roads, must play in the very near future in all kinds of world activities in order to improve the living standard in many regions. He contends that local roads are the beginning and the end of a large part of the global traffic in food, minerals, and forest products. He remarked that if rural and low volume roads do not have enough resources, the present situation may find the world without adequate supply lines to the cities and without the necessary rural access rural roads to make possible the provision of food and other resources needed for the economic survival of both city and country. Professor Owen also called for an international effort of cooperation as a possible way to create a global network of organizations that would focus responsibility for extending and improving the world's transport capabilities. He pointed out that this kind of road means a way to provide benefits for a better education, health, housing, labor, life. He ended by calling to our attention the disease of the mother world: an imbalance in terms of wealth, power, culture, attraction, and hope. But creating new hope for the isolated and forgotten in rural areas all over the world would be a challenging assignment entrusted to this international conference. This philosophical thought is in agreement with the Mexican position expressed by the Minister of Communications and Transport during the Ninth World Meeting of the International Road Federation held in Stockholm. There Mr. Felix stated, "If the future can, at times, be forboding it remains, undoubtedly, full of opportunity and promise." The optimistic spirit with which we all face the future, and the efforts made to shape it, assure us of such fine results. From this framework of hopes and fears we chose the right perspective for our theme. Low volume roads will possess strategic importance in the future. As a consequence, developing nations must take the lead in conceiving and applying those instruments appropriate to their own reality and needs as well as to fulfilling their own requirements.

Finally, three basic elements most certainly shape the framework of our actions to modify and improve human living conditions: liberty, justice, and respect for others. There pertinence and exercise characterize the true sense of progress. Their is no growth without freedom; no humanization without justice; no fraternity without respect. Together they comprise the highest goal of humanity: peace, with freedom, justice, and respect for others. Roads in the future should be roads to harmony. Indeed roads to peace. I do thank you very much.

*CALIBRATING AND STANDARDIZING ROAD ROUGNESS MEASUREMENTS MADE WITH RESPONSE TYPE INSTRUMENTS

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The UK Transport and Road Research Laboratory road roughness calibrating and standardizing beam was developed to provide a calibrating capability for response type road roughness measuring systems (RTRRMS). This development was based on past TRRL experience in the field of roughness measurement in developing countries. The concept of "ride comfort" as adopted in the developed world as a direct measure of the unevenness of a road surface as perceived by the road user was not applicable to the road conditions met in developing countries. In such countries ride comfort and level of service do not have the same importance as in the developed countries, as the greater need is for more roads to provide the basic means of transportation and communication which are operable through the year. Because of shortage of resources for building and maintaining all weather roads, a lower serviceability rating is tolerated by the user. However, the lower quality of the road surface manifests itself in higher vehicle operating costs through greater wear and tear of the mechanical components of the vehicles. Comfort to the vehicle rather than to the rider takes on a greater importance. There is very little evidence to suggest what measure of roughness is most appropriate to relate to the effects of "vehicle comfort." Measures in use have been generally selected on the basis of convenience, simplicity and past experience of investigators, and the most popular measure has been the output of RTRRM's which measure the displacement of the axle relative to the body of the vehicle induced by the roughness of the road it is traversing. The magnitude of these response type measurements varies according to the suspension characteristics of the vehicle used and also with time due to a change in these characteristics through usage. Such measurements are acceptable only if they could be calibrated to a given standard enabling measurements with different vehicles at different periods in time and space to be related to that standard. In spite of these serious drawbacks RTRRMS enjoy a great popularity with practicing engineers and researchers and are in widespread use throughout the world. It has been accepted that this method of measurement will prevail for some years to come and therefore the necessity to provide a viable and readily available calibration system is urgent.

An alternative to the RTRRMS measure of roughness is a profilometry based measure of roughness, and is an obvious candidate for providing a calibration reference for calibrating measurements of RTRRMS. A major requirement of any profilometer based system is that it should have the ability to accurately measure the longitudinal profiles of test sections of road, and also be able to be calibrated independently of other measuring systems. It also requires a method of processing the profile data to yield a single roughness statistic to describe the profile for subsequent correlation with RTRRMS measures.

A successful calibration system based on profilometry for use in developing countries needs to satisfy three important conditions. The calibration system/instrument must be easily transportable particularly from country to country. Appraisal studies undertaken by consultants for developing countries are usually of short duration. This means that unless the instruments can be easily transported to the country and the site, they will not be used by practicing engineers and consultants, however good they may be. Secondly the instrument must be reasonably simple to operate, and data management, analysis and interpretation available immediately after measurement. Manual data processing cannot be undertaken by field staff, therefore the generation of profiles alone in the field and the creation of a large data bank without the capability of instant computation, analysis and presentation of calibrated results is not acceptable as a viable method of calibrating roughness measurements. The last and equally important consideration is the cost of such an instrument. The instruments available at present are highly sophisticated, and very expensive to acquire, which effectively puts them out of the reach of practitioner.

These three conditions guided the TRRL's approach to the computation of a suitable numeric for correlation with RTRRMS measurements and the subsequent development of the beam as a viable roughness calibrating and standardizing instrument, independent of external computational requirements.

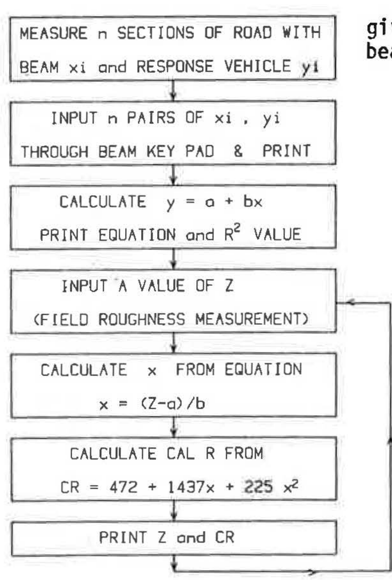
The Calibrating and Standarizing Process

Calibration of response type instruments is achieved through the computation of the root mean square of deviation (RMSD) of the road profile of the test section for base lengths of 1.8 meters using profile intervals of 300 mm.

The procedure for calibration is to select a number of sections of road approximately 200-300 meters in length, covering a range of roughness levels and containing as many road surface types as possible (a minimum of 10 sections is recommended). These sections are then profiled on the nearside wheelpath with the TRRL beam and the Root Mean Square of Deviation (RMSD) statistic computed for each section. The sections are also measured with the response type vehicle mounted roughness measuring instrument at a speed of 32 km/h. A linear regression of the form $y = a+bx$ is calculated using RMSD as the independent variable (x) and the RTRRMS measures as the dependent variable (y). This equation now constitutes the calibration equation for that particular RTRRMS.

Calibrated roughness measurements made with different instruments need to be standardized on a universally acceptable scale to achieve comparability between instruments and also transferability between countries. The standardization recommended is based on the response characteristics of the TRRL towed 5th wheel bump integrator. A standard reference roughness equation was developed by relating the towed 5th wheel bump integrator measurements to the root mean square of deviations of the road profiles. Figure 1 illustrates the relationship and the equation is:

Figure 1. Flow Diagram of the Operation of the TRRL Roghness Calibration Beam



$$ROUGHNESS = 472 + 1437\,(RMSD_{1.8/300}) + 225\,(RMSD_{1.8/300})^2 \quad .....(1)$$

The above standard reference roughness equation will remain a permanent road roughness estimator through time and space.

Routine field roughness measurements can now be made with the response instrument. These routine measurements need to be calibrated and standardized in the following manner. Substitute each field measurement for y in the equation $y = a+bx$ and calculate x from $x = (y-a)/b$, to produce an estimate of RMSD as perceived by that particular RTRRMS. This estimated value of RMSD is then input to the standard reference roughness equation (equation (1) above), to produce a standardized roughness value. All the field measurements are standardized in this manner.

OPERATION OF THE TRRL ROUGHNESS CALIBRATION AND STANDARDIZATION BEAM

The TRRL beam has now been developed as a compact, self contained road roughness calibration and standardization system. The road profiles measured by the beam are processed automatically through its internal microprocessor and the root mean square of deviation is printed out at the end of the measurement of the test section. After measuring the required number of test sections, the operator is required to input the RMSD values for each section together with the RTRRMS measure through the built-in key-pad to compute the calibration equation. The equation is also printed together with the value of R^2. The equation is printed for the operators information only, although he does not need to use it. The R^2 value will be printed with a warning that the correlation is not satisfactory if the value falls below 0.90. After the equation has been computed and printed, the operator inputs his routine field roughness measurements in mm/km and the processor will print the calibrated standard measure of roughness which will be expressed in mm/km for a standard speed of 32 km/h.

A flow-chart of the operation of the beam is given in Figure 2 and an illustration of the beam is shown in Figure 3.

Figure 2. Flow Diagram of the Operation of the TRRL Roughness Calibration Beam

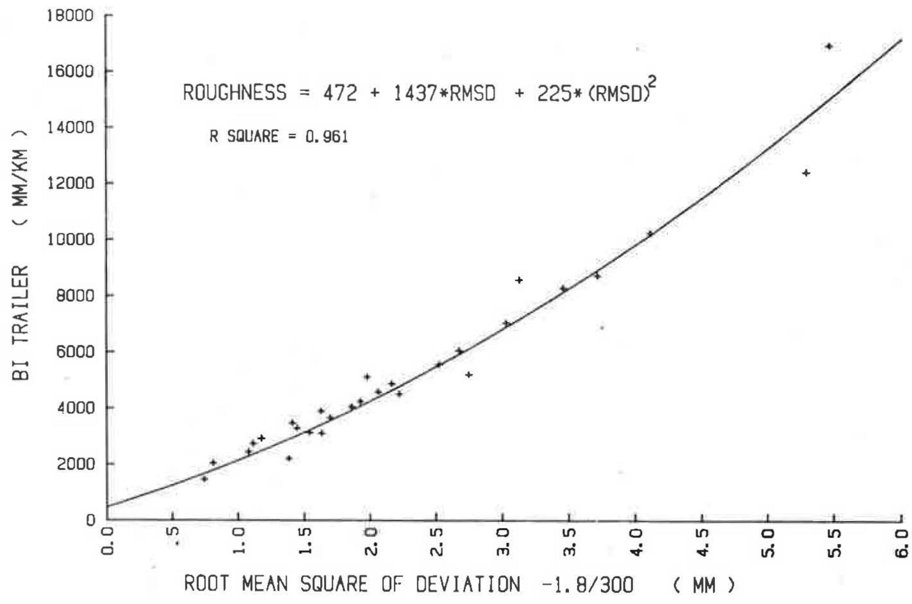
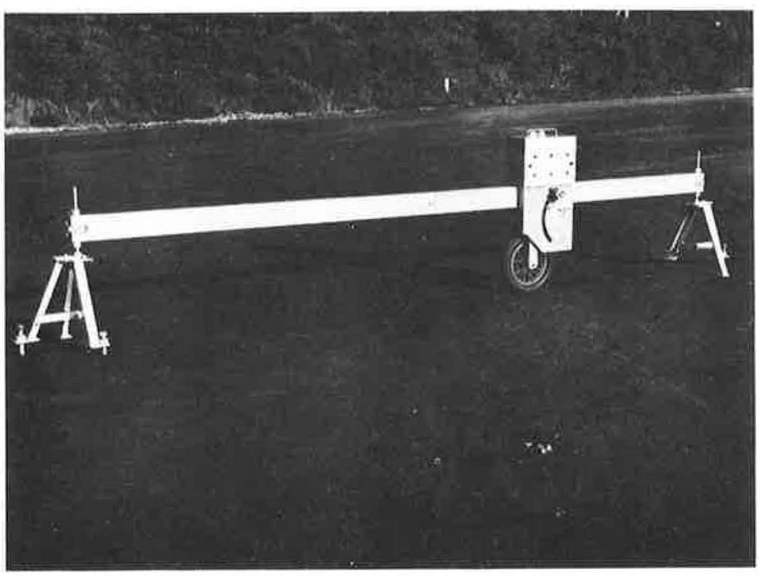


Photo 1. TRRL Roughness Calibration Beam



**This material was unavailable when TR Record 898 was printed. It is included here so that the content of Dr. Abaynayaka's conference presentation will be recorded.*

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ERRATA FOR TRANSPORTATION RESEARCH RECORD 898
LOW-VOLUME ROADS: THIRD INTERNATIONAL CONFERENCE

"Socioeconomic Evaluation and Upgrading of Rural Roads in Agricultural Areas of Ecuador"
Jacob Greenstein and Haim Bonjack

1. Page 93, Left Column, Line 51:

   A=20 should read A_j=20
   A=70 should read A_s=70

2. Page 93, Left Column, Line 58:

   The formula should read,

   P_{dj} = 4 x (1590 x 0.01 (20/2 + 70 x 0.9) + 4000 x 0.005 x 70 x 0.1) = US $5,203

"Pavement Evaluation and Rehabilitation of Low-Volume Roads"
Louis Berger and Jacob Greenstein

1. Page 192, Table 1:

   The value of $\epsilon_z E_{s/p}$ for example C, reference section should be 0.22, not 0.51 as indicated.

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