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ASPHALTIC ROAD DESIGN
DP/CHI/84/009
CFILE

Technical Report*

Prepared for the Government of the Republic of Chile
by the United Nations Industrial Development Organization
acting as Executing Agency for the United Nations Development Programme

Based on the work of W.R. Hudson,
Consultant in Road Construction and Maintenance

United Nations Industrial Development Organization
Vienna

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November 25, 1985

**FIELD TRIP TO SANTIAGO CHILE IN ACCORDANCE WITH
UNIDO POST DP/CHI/84/009/11-51-32.1.B**

I arrived on Wednesday November 13, and was met at the airport by Alfredo Serpell. The complete schedule of my visit is appended as attachment A to this report.

SUMMARY:

This technical visit was in my opinion very successful. The field trips were very helpful in obtaining an overall understanding of the project underway. During these field trips it was possible to get better acquainted with the project staff at The Catholic University and also with representatives of the Ministry of Transport. It was particularly useful to become reacquainted with my friend Engineer Jorge Salgado.

I had technical discussions at various times with members of the faculty of the University and with Members of the Ministry of Public Works, particularly the Direccion de Vialdad. While we primarily discussed research associated with flexible pavements, pavement evaluation, and pavement management, I also had the opportunity to discuss improved cooperation between the University of Texas and the Catholic University. I believe we have a good basis for continued and improved cooperation.

From the discussions it appears that the research project is progressing at a reasonable pace although many of the problems associated with field research of this type were discussed and will be addressed in this report.

Finally, the International Technical Symposium on Design Construction and Maintenance of Asphaltic Pavements was very successful. It was a real pleasure to cooperate with Dr. Martin Snaith of Birmingham University, Dr. Alex Visser of NITRR South Africa, and Mr. Peter Spratz of Spain, a special consultant to the Ministry.

After evaluating the situation and carrying out important discussions, it is my recommendation that the second month of my contract for 1986 be signed and completed as soon as possible in order that appropriate visits may be scheduled. After discussions with Mr. Gregorio Azocar, we feel strongly that this support should be divided into two visits; one in the early part of the year, and the other one, in the latter part of the year depending on the progress of the project, so that scheduling my own participation can be clarified at the earliest possible date.

BACKGROUND

The field trips throughout Chile underlined the importance of the research projects which are being carried out. Chile is presently undergoing and planning a very large program for pavement evaluation and rehabilitation. The methods to be produced in the research underway at the Catholic University and in the Ministry will undoubtedly provide a great improvement in design methods for future use. At the present time, the AASHTO Interim Pavement Design, dated 1972, is being used by the MOP (Chilean Ministry of Public Works). This guide has been completely revised in the United States during 1985. It is my suggestion that a copy of the revised guide be included in the project for consideration as a document for future use and modification in Chile. I will obtain the document and will be taking it to Chile on my next trip.

As a part of this trip, I carried approximately ten technical papers and reports which I deposited with Mr. Azocar for use on the project and in the symposium. I will continue to provide support during the next 18 months or as long as my involvement with the project is desired continued.

The technical staff assigned to the project by the University is well qualified. It is recommended that a detailed work plan be set forth at this point with critical steps to be outlined for future work. It is essential that milestones of accomplishment be set up for the next three years with the solution of the overall project to be completed at the end of that time. Clearly, the improvement of pavement design, construction and rehabilitation in Chile will continue past the end of this project. However, appropriate deliverables or output from this project should be insured at the end of the existing time.

In reviewing the project, it seems very important to me that there be good interaction between the project at the Catholic University and the overall database for flexible pavements which I understand is being developed by the Vialidad in conjunction with the University of Chile. I believe it will be important that the input from the flexible pavements in this project be closely coordinated with the Catholic University project. Possibly, a mini-database should be set up on a micro computer at the Catholic University with data being developed, maintained, cleansed, processed, and provided to the main database. I would like to discuss this in more detail on my visit in early 1986.

I particularly enjoyed the opportunity of meeting the Minister of Transportation and discussing with him and with his representatives the progress of the project. It was also useful to meet with the various Directors or Chiefs of departments of the Vialidad. It was very enjoyable to have the opportunity for additional interaction with Enrique Sepulveda Chief of the Construction Department, and Mr. Y Jaime Carravinaana, the Chief of the Department of Design.

It was a special pleasure to have the opportunity to interact with Alex Visser, one of my former students, and with Dr. Snaith of the University of Birmingham in Britain. The three of us compared notes a number of times, and I believe we are in general agreement on the approach taken to this project. I am sending a copy of this report to them and I hope they will comment in their own way on the various aspects of the project.

OVERALL COMMENTS ON THE PROJECT

As mentioned above, I believe the project is an important step forward for the construction and rehabilitation of the road network of Chile. I think it is timely. The major program undertaken is to improve and redevelop Chile's road system. It is also important to the World Bank activities involved in funding such projects as well as the funding from BID. It was an especially good idea to get both Universities and MOP involved in this project. However, it remains an important task to keep

There is between the three projects and the reports of the projects closely coordinated. The availability of the database on flexible pavements to the Catholic University will be of particular importance for the ultimate presentation of results on their project.

In some ways I may have seemed negative in my discussions to the members of the research team. However, it is my desire to bring realism not negativism or pessimism to the project. I think it should be realistically considered that the measurements from the GM Profilometer being purchased from KJ Law may not really be available until early 1986. It is strongly recommended that the work on the database, particularly the measurements of roughness should begin immediately with the Maysmeter. It is equally important that the measurements from the Maysmeter be properly calibrated using rod and level surveys. Procedures for this technique have been presented and implemented by myself in Panama and Argentina and by others in Brazil and elsewhere. We would be glad to assist in this effort if necessary. However, an additional work level would be required as well as the provision of an associate of mine from the United States.

It is my understanding that the Deflectograph has been purchased and will be delivered in March 1986. I believe that the measurements of surface deflection basins will be the keystone measurement of behavior and structural condition of the pavements in this study. I strongly recommend that the Deflectograph be evaluated at the earliest possible date in terms of its capabilities and applicability to flexible pavement sections. Again, a note of concern, In 1977-80 I was involved with the purchase of five Deflectographs and their implementation in Argentina which as you know is not far from Chile. Unfortunately, the advertised capability of these devices to measure the deflection basin was never realized and the complexity of the equipment was such that they never operated effectively over long periods of time. I hope that every attention has been given and can be given in the future to insure that the device purchased for Chile will be made operable at the earliest possible date and will be used effectively for the flexible pavement studies.

My own experience suggests that, if the Deflectograph causes trouble or is not effectively available on a regular basis for the research on the flexible pavements, the purchase of one DYNAFLECT at a cost in Chile of approximately U.S. \$40,000 would provide the necessary instrumentation.

DETAILED PRELIMINARY ANALYSIS

It was discussed and agreed by all involved that the 18 test sections being studied for flexible pavements do not alone provide adequate information for the development of models of flexible pavement behavior and performance. Rather, these are case studies which can be used to calibrate and adapt or adjust existing theoretical models to Chilean conditions. It is my firm belief that the performance history of the pavement network existing in Chile of some 5,000 kilometers of flexible pavement will in fact provide the best overall set of data for development and modification of models.

It is also my feeling that the revised AASHTO Pavement Design Guides (1985) offer an extremely good potential as a set of theories for adaptation and modification for Chilean use. I say this because they reflect approximately U.S. \$1,000,000 of adaptation and use of existing research technology within the past 18 months in the United States. There is certainly nothing magical about work in the U.S.A., but this particular compilation of recent work offers a unique opportunity for Chile to take advantage of work done by others and not to have to spend this amount of money again. Clearly, the work being done in the existing project in Chile will at least require you to adopt models for the potential of early success and a basis for comparison and adaptation.

A number of detailed analyses and steps in the analysis procedure are required in the project. It is recommended that work be undertaken immediately to make interim decisions on methods of analysis and that a "dummy" analysis be run for the various procedures to insure that the sensitivity and the approach being taken is reasonable.

For example, it is important to develop a method of determining a modulus of elasticity from the field measurements which have been taken in the test sections. It is my understanding that the field measurements taken were CBR. There are a number of ways of adapting CBR to modulus of elasticity. They should all be tried and a tentative method should be selected for early use in this project. It is also important that a method be selected for use in matching deflection basins to deflection information on the sections to calculate a modulus of elasticity for the individual layers. This should be thoroughly thought out and it is hoped that preliminary consideration and recommendations will be presented by the project staff for my visit which has been preliminarily scheduled for March 1986.

INTERNAL DEFLECTION MEASUREMENTS

A great deal of time was spent discussing the measurements of internal deflections at the various layered levels within the 18 test sections. It was reiterated to the project staff that the work done in South Africa has been done at one location at a time for a period of about 3-6 months while intensive traffic changes were taking place as applied by the heavy vehicle simulator equipment. This is quite different from going to 18 different test sections at various times over a period of three or more years. I consider it highly unlikely that effective measurements can be taken under these conditions in Chile. It is more reasonable to apply the technology which has been developed in the past year to controlled test sections to be constructed on the University campus. It would be wise to use surface deflections and deflection basin measurements from the test sections along with the measurements of deflection basins to be carried out by the acquired Deflectograph or the Dynaflect to provide information for determination of in-situ pavement material properties.

A great deal of discussion was carried out on the comparison of field surface moduli and laboratory measured moduli. It should be remembered in this regard that the primary purpose of measuring moduli in the field is to evaluate pavements for rehabilitation or overlay design. Under these circumstances it should be remembered that the observed moduli in-place are probably the material properties which will govern the behavior of the overlaid or rehabilitated pavement. Under these circumstances it is

suggested that the field values of modulus are in fact the appropriate values for use. In terms of the particular research, however, it is important that both field and laboratory measurements be compared with the laboratory values of strength vs. various stress levels for further evaluation.

SUMMARY RECOMMENDATIONS

It is recommended that a revised detailed work plan be prepared at the present time to present a step-by-step procedure of all the analyses to be undertaken and actually to undertake preliminary analyses directed toward the type of information which are to be presented in the final project results.

It is recommended that close coordination be maintained between MOP (Vialidad) and the project to insure that the database for flexible pavements be quickly and completely available to the Catholic University for overall use in their portion of the project.

It is recommended that the measurements of pavement roughness be commenced on the entire network of flexible pavements immediately. This will probably be done with the Maysmeters. However, the Maysmeters should be calibrated with rod and level surveys on at least 25 calibration sections in the very near future. The KJ Law profilometer will actually be available for work sometime in 1986. At that time it will provide the calibration necessary for Maysmeters in the future and should be back calibrated to the existing information. However, the database should not be delayed waiting for the KJ Law Profilometers.

Close coordination should be maintained in the testing development of the Deflectograph. Pavement measurement should be undertaken at the earliest possible time to insure that good deflection basins can be measured. In my opinion the deflection basins for the test sections and in fact for many miles of the flexible pavement system will be the keystone information to be used in modifying and adapting additional available theories for this project.

It is recommended that available layered system analysis models be obtained and used and that all models or analysis methods be obtained from the existing literature and existing models whenever possible. A great deal of work has been done all over the world in this theoretical area. It would be in my opinion an unfortunate waste of Chile's resources to reinvent or redo any of these available programs. Layered theory is independent of country, language or any other concern. The splendid work done in the past in England, Holland, and The United States is certainly quite applicable to the behavior of pavements in Chile.

On the other hand empirical and other information being developed from field observations in Chile will be unique in adapting the results and the methods for Chile.

FINAL SUMMARY

In summary, it has been a real pleasure to visit Chile and to interact with the outstanding personnel there on this important subject of pavement rehabilitation. I look forward to the possibility of visiting the team in 1986 and hope that it will be possible to make the first visit in March of that year.

Enclosure: Attachment A schedule activities

SCHEDULE OF ACTIVITIES

DR. RONALD HUDSON'S VISIT TO CHILE

November 13 to November 22, 1985

WEDNESDAY 13

- 20:15 Arrival to the airport. Transportation to the hotel Los Españoles.
- 22:00 Meeting with Gregorio Azócar, Head of The Department of Construction Engineering, at the hotel.

THURSDAY 14

- 09:00 Trip to the airport.
- 10:45 Departure flight Ladeco #077 to Puerto Montt.
- 12:20 Arrival to Puerto Montt. Lunch.
- 14:00 Work trip Puerto Montt - Puerto Varas - Ensenada - San Pablo - By pass Valdivia - Loncoche - Pucón
- 19:00 Arrival to Pucón.
- 21:00 Dinner and lodging at Pucón.

FRIDAY 15

- 09:00 Work trip Pucón - Temuco.
- 13:10 Departure flight Ladeco #014 to Santiago.
- 14:15 Arrival to Santiago. Hotel.
- 15:00 Free

SATURDAY 16

09:00 Trip Santiago - Viña del Mar.
11:00 - 13:00 Tour around Viña del Mar and Valparaiso.
13:00 Lunch. Sea food at Higuierillas.
15:00 - 19:00 Reñaca Beach or tour to Zapallar, Cachagua, etc.
21:00 Barbecue at A. Serpell's apartment.
22:30 Casino Viña del Mar.

SUNDAY 17

09:00 Work trip Viña del Mar - Casablanca - Algarrobo -
San Antonio - Santiago.
18:00 Tentative arrival to Santiago. Free.

MONDAY 18

09:00 Meeting with Ministry of Public Works (MOP)
Authorities.
10:00 Press Conference.
12:30 Meeting with Rector of The Catholic University of Chile.
13:00 Lunch with MOP's authorities at Club de la Unión.
15:00 Simposium Opening Ceremony.
15:45 - 19:00 Dr Hudson's lecture.
21:00 Dinner with Gregorio Azócar and Alfredo Serpell at
Hereford Grill.

TUESDAY 19

09:00 - 13:00 Work session on campus.
13:00 Lunch with United Nations Development Programme



Universidad Católica de Chile
Escuela de Ingeniería
Departamento Ingeniería de Construcción

representatives, Gregorio Azócar and Alfredo Serpell at Enoteca.

15:00 - 19:00 Symposium. Dr Snaitth's lecture.
21:00 Dinner at Gregorio Azócar's house.

WEDNESDAY 20

09:00 - 13:00 Work session on campus.
13:00 Lunch at Casino School of Engineering with professors of the Construction Engineering Department.
15:00 - 19:00 Symposium. Dr. Visser's lecture.
21:00 Dinner at Hernán de Solminihac parent's house.

THURSDAY 21

09:00 - 13:00 Work session on campus with Construction Engineering Department researchers, A. Visser and M. Snaitth.
13:00 Lunch with professors of the School of Engineering.
15:00 - 19:00 Symposium. Mesa Redonda.
20:00 Dinner with Dean of The Faculty of Engineering, MOP's Authorities, A. Visser, M. Snaitth, and professors of the Construction Engineering Department.

FRIDAY 22

09:00 Trip to the airport.
10:00 Departure Ladeco flight UC300 to Miami.

I GOOD TRIP & OK HOME!