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9. ABSTRACT

A report on three different consulting projects conducted in the Dominican Republic in March and April, 1976. The first concerned a review of new grain storage and handling facilities in Santiago. The silos were found generally well constructed, but exhibit certain design weaknesses and failure to meet specifications. Fifteen specific problems are listed. The second project concerned evaluating a plan for development of a network of Rural Marketing Service Centers. Detailed recommendations are made concerning the need for a feasibility study to establish the number, type, locations, and sizes of the warehouse/purchase/sales facilities, as well as a financial accounting system for effective administration of the centers. The third project concerned inspecting a grain storage and handling facility constructed in Santiago in 1969. Since 1973 the facility has settled unevenly several inches, setting askew interior conveyors and man lifts. The loading history of the facility is reviewed, and details of the facility distress discussed. It was concluded that further uneven settlement is extremely unlikely; that the internal machinery can be buttressed independently; and the facility can be reloaded and used normally, provided that monthly measurements for possible differential settlement be made under the supervision of a competent structural engineer.

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PART II - Proposal Review for Rural Agricultural Marketing Centers

PART III - Renovation of Storage and Handling Facilities at Santiago

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PART III - Donald S. Jack, Consulting Engineer, Kansas City, Missouri

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Principal Investigator: PARTS I and II - Dr. Harry Pfost

PART III - Donald S. Jack

SUMMARY STATEMENT

PART I

A review of the problems in receiving and constructing new elevators (silos) in the Dominican Republic was initiated by Dr. Pfost and C. Hugo. A problem with the settling of a new elevator at Santiago was surveyed by Dr. Pfost and recommendations for further investigations by a structural engineer were suggested. The team also reviewed proposed new port unloading facilities. It was recommended that a more thorough feasibility study would be desirable.

PART II

As requested, the proposed new agricultural marketing center plan was reviewed by the team. It was determined that much more information was needed but that experience in other developing countries has shown the center concept to be particularly beneficial to small farmers and leads to overall marketing efficiency improvement. A feasibility study was recommended and the information needed was outlined for a survey.

Mr. Don Jack, consulting engineer from Kansas City, Missouri, was retained by Kansas State University to follow up the recommendations by Dr. Harry Pfost, that a structural engineer evaluate the settling problem of a concrete grain elevator constructed in Santiago, Dominican Republic.

It was recommended that the elevator be put back into use without any foundation repair. The repair of all machinery and the isolation of all framing was a mandatory prerequisite, before continued operation, so that equal settling of the foundation can take place in the future. It was felt that there was no danger of the silos cracking if the foundation was allowed to settle uniformly.

ASSESSMENT OF
GRAIN STORAGE AND MARKETING FACILITIES
IN THE DOMINICAN REPUBLIC

Prepared by

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I. INTRODUCTION

A Kansas State University grain storage team was requested by the Interamerican Institute for Agricultural Sciences (IICA) through USAID in conjunction with the IICA/SEA integrated marketing project to study certain problems related to grain marketing in the Dominican Republic. The team of one engineer and one agricultural economist arrived on March 10 and departed on March 24, 1976.

While in the country, they consulted and worked with persons in USAID/AGR., IICA, SEA (Secretary of Agriculture of DR) and INESPRE (Institute for the Establishment of Prices for Agricultural Products).

The economic study reviewed some of the available published and unpublished information related to agricultural product marketing and past and planned data acquisition. A brief field trip to the major agricultural production areas provided an insight into the present agricultural capabilities and problems. Suggestions for analyzing, collecting additional data and completing the feasibility study and analysis is in Section III.

The engineer reviewed the plans and specifications for the silos now nearing completion and made an on-site inspection of two of them. Detailed discussions regarding possible needed design changes were held and are summarized in this report. Steps to be taken to test the performance of the silos before accepting them are also summarized.

Problems of foundation settling of the Santiago silo were discussed and soil test data and structure plans were taken back for further consultation with appropriate engineering specialists. Recommendations for another engineering visit were made and the results discussed in Part III of this report.

Problems of unloading and storing imported grain were discussed. Cost estimates of proposed facilities were reviewed and appear reasonable. The feasibility study was not seen. Suggestions for consideration during a further feasibility analysis, if desired, are presented.

Mr. Donald S. Jack, consulting engineer from Kansas City, Missouri, was retained through Kansas State University to investigate a reinforced concrete grain elevator which was constructed in the city of Santiago in the Dominican Republic. The grain elevator had been erected, at least in part, by Alliance for Progress assistance in 1967-69.

Mr. Jack arrived in the Dominican Republic on April 7, 1976 and departed on April 16, 1976. It was reported to Mr. Jack that the storage unit had developed some wall cracks and that settlement had taken place in such a fashion that it's usefulness had been questioned by the owner, Instituto de Estabilizacion de Precios (INESPRE), to the point that it was taken out of usage as a storage unit about mid-1974, except for very light loadings.

The structural design of the storage unit was accomplished by Paul H. Brown and Associates Inc. of Raleigh, North Carolina. Mr. Paul Brown forwarded certain original plans and soil investigations to Mr. Jack prior to his departure. The soil investigations for the Santiago project were conducted by the Labatorio De Ingenieria of Santo Domingo, Dominicana. Construction of the complex was done by Dominican contractors - Ingenieria General and Vargas Mera.

The teams wish to express their appreciation to the many people who helped make this study possible. Particular thanks are due to Dr. Ronald Pollock, USAID; Jerry LaGra, IICA/SEA, Coordinator; Dr. H. Morales, IICA; Agr. Diego Pla, SEA; and Ing. Francisco Viñas of INESPRE.

PART I REVIEW OF GRAIN STORAGE AND HANDLING FACILITIES

A. NEW SILOS

Plans and specifications for the new silos were checked to see if they conformed to standard engineering design practice.

Generally the design and the equipment specifications appear to be good. One question which is not answered in the specifications is whether the silos are designed for grain in general, including corn, or whether they are designed only for rice. Plans were checked by a structural engineer and they appear to be structurally sound for corn and beans. Soil test data will also be checked to determine if the bearing capacity of the soil is adequate.

INESPRE engineers acted as inspectors during building construction and reported that the concrete tests showed adequate strength and that reinforcement placement was properly done.

Physical inspection at the site of two of the silos showed generally good construction practice and craftsmanship. Points such as these include:

1. Welding appeared to have been done by experienced craftsmen.
2. Sheet metal work, such as spouts, is good.
3. Conveyors have been carefully installed to assure alignment.
4. Electrical wiring is in good physical condition.
5. Machines appear to be well mounted.
6. Concrete finish appears to be good.

Overall it appears that the contractors and subcontractors have attempted to fulfill the specifications of the contract.

Certain weaknesses of the design and failure to meet specifications and/or good practices include:

1. The receiving system is poorly designed. No provision was made for receiving bulk grain. This feature can be incorporated later and a possible design was discussed with Ing. Viñas.

2. The system for receiving sacked grain is inadequate. A paved concrete ramp and roof should be provided for the truck being unloaded. The receiving side of the dump hopper should be cut down to floor level so the sack dumper does not have to lift sacks. The grill in the receiving hopper should be slightly below floor level.

3. At one silo the aspiration duct to the receiving trash conveyor was not flared to reduce the air velocity.

4. The skip hoist for precleaner trash appears inadequate in capacity and may have to be replaced. A pneumatic system would probably be the best solution if a problem develops. The pneumatic system should be a negative-positive pressure type with a materials-handling type centrifugal fan.

5. Bins which store trash and cleanings have hopper bottoms which may be too flat and the openings are probably too small. These bin bottoms may have to be replaced with wedge-shaped hoppers (one side vertical) and multiple screw discharge devices.

6. Spouting and hopper slopes in the flow where wet rice is handled may not be steep enough in a few places. Some rice of perhaps 24 percent moisture should be tried.

7. Good bucket elevator design practice in the U.S. would now include lagging on the head pulley and a motion switch on the lower pulley. This will prevent the possibility of a fire if the elevator plugs.

8. A gutter was not provided under the eaves of the silo roof. A water drip flashing should be provided. The gutter was installed on some of the headhouse roofs as called for in the plans.

9. Explosion-proof covers for light bulbs are not in place but are on hand. The covers should be installed and the light intensity checked with a light meter to determine that the light intensity specifications have been met.

10. In the dust collector system, adjustment valves are not being installed at each entry point. These will have to be installed to satisfactorily balance the system during start-up.

11. Pneumatic pipe fittings which had been cut and threaded on the job had not been reamed. This point should be checked.

12. Gaskets are not in place on some electrical conduit fittings. These should be used to prevent dust from entering the conduit.

13. No fire escape on the exterior of the building has been provided. Men would be trapped in case of fire inside the building.

14. If the silos settle unevenly after loading, it is going to be difficult to replumb the elevators because of nearby concrete floor beams and other obstructions such as stairways.

15. A permeable drained wall in the soil around the silo has been proposed to reduce seepage into the silo pits. This may be desirable and should be discussed with a soil or structural engineer.

The above deficiencies should be discussed with the contractor before starting the facilities.

After the contractor has stated, in writing, to the client that the facilities are complete, the client should provide adequate quantities of rice to

test the facilities. The contractor should conduct these tests under the supervision of the client. In case any deficiencies, errors and omissions are found they should be corrected to the satisfaction of the client. At this stage of the project, the contractor(s) should be given all necessary cooperation by the client in furnishing required personnel and grain. A final letter of acceptance should not be issued until the client is satisfied that all contract obligations have been met.

Steps which should be followed during the start-up include:

1. Lubricate all bearings which require lubrication, check the oil level in all gear boxes and determine that no bearings are frozen.

2. Inspect all chains and belts for proper tension. Make sure that all multiple V-belt drives have matched length belts. All belt and chain guards should be in place.

3. Inspect all motors to determine that they meet specifications and are not rated for more than 40°C. temperature rise. (All motors checked were adequate.)

4. Start each machine separately and determine that it is running in the proper direction. If not, change the electrical connections. If the machine would be damaged by backward motion, disconnect the motor from the machine until the motor direction has been determined. The machine should be observed to determine that there are no unusual noises which might indicate bearing problems, improper alignment, improper adjustment, etc. Observe all flat drive, conveyor and bucket elevator belts to determine that pulleys are properly aligned as indicated by the belt remaining centered on the pulley. Idler pulleys on troughed belts may need alignment. Sometimes new belts may be "warped"

and can never be made to run correctly. (During this phase, adequate telephone or other communication should be provided between men who are observing the machine and the person who is at the electrical control.)

5. Introduce grain slowly into the system to determine that machines are operating properly. Probably the first 30 tons can be held in the driers to use as a preliminary test of the drier capacity. Burner adjustments can be completed.

6. The driers should be capable of meeting the capacity specifications without exceeding a temperature of about 70°C. Higher temperatures will damage rice quality. Burners will have to be adjusted for proper combustion. The rice should be dried to normal storage moisture before leaving the drying-tempering area because spouting later in the flow is not designed to handle wet rice.

7. Circulate the first 30 tons of rice through every conveyor and bin to make sure that all machines are working and also to remove foreign material left from the construction. This first rice will contain so much foreign material that it should be destroyed.

8. The facility should now be ready to test at normal operating capacity and conditions. Specifications to be checked include:

a. Cleaner performance

b. Conveyor and elevator capacities

c. Hopper design

d. Spouting design

e. Dryer capacity.

9. As bins are filled, the loading on the footing should be kept as uniform as possible by alternately filling bins from side-to-side and end-to-end. Fill bins in at least four stages.

10. Soil compaction is a relatively slow process. The soil will allow the silo to settle and about 80 to 90 percent of the settling should occur during the first year.

11. Since the silos appear to have been designed for corn it would be desirable to fill completely and test load with corn for at least 6 months. In any case, a full load of rice and/or corn for 1 year will be desirable.

12. Failure to subject the silos to this original settling may bring trouble later when someone may have forgotten that the settling was not done and will improperly load the silos. Also if settling is very uneven some equipment will have to be realigned. As noted above, this may be a difficult problem with the bucket elevators.

During the testing and start-up period, INESPRE may desire to employ an outside consulting engineer to aid their own engineers in assessing the quality of the facilities.

B. PROPOSED NEW PORT FACILITIES

Cost estimates for the possible port facility at Haina were reviewed. The cost of this facility is estimated to be about (US) $420/MT. This compares with a similar facility built in Tunis, Tunisia about 4 years ago at a cost of about $300/MT and a port facility proposed for Alexandria, Egypt and estimated to cost about $370/MT in May 1975. The overall cost is about (US) $4,700,000.

There is no doubt that considerable ship demurrage is now being experienced when unloading corn. However, this is a relatively small amount and demurrage should not exceed about 40 days per year, which represents about $240,000 per year.

If a final decision has not been made to build this facility, a more thorough feasibility study would be desirable.

Some alternatives which should be considered include:

1. Make greater use of the present and proposed ship unloading facilities of the flour mill of Molinos Dominicanos. At present import rates of maize and wheat the present facilities, which can unload 2,000 T/day, would be used less than 10 days per month. When the flour mill facilities are expanded as is now proposed to a capacity of 5,000 T/day, the facilities could unload the present imported maize and wheat in about 3 days per month.

2. If the present rate of rice imports is continued, the existing unloading facilities would not be particularly pressed if rough rice were unloaded through the flour mill facilities. Hopefully, the country will again reach self-sufficiency in rice.

3. Consideration should be given to splitting shiploads -- half wheat and half corn. This should relieve problems of storage capacity for both INESPRE and Molinos Dominicanos.

4. If 10,000-ton loads of maize must be imported, then a feasibility study should confirm the excessive cost incurred because of the present scarcity (about 12,000 Ton) of existing public and private storage for maize imported into and used by feed manufacturers in Santo Domingo. Usually storage for one and one-half to two loads (15,000 to 20,000 Tons) is required for a

smooth operation. Probably an additional 5,000 Ton storage would be justified. However, consideration should be given to locating this storage to the east side of the river and on higher ground. This should reduce truck requirements during ship unloading and eliminate cost for piling.

A 5,000 Ton facility using metal storage bins should be built for about (US) $60/MT or a total cost of about $300,000.

5. The receiving rate at the Herrera silo is too low for its present and future use if ship unloading time is to be reduced significantly. A receiving rate of nearer 250 T/hour would be desirable if shiploads were split or perhaps 150 T/hour if a new facility were built for 5,000 Ton. This receiving rate would require the installation of a new receiving pit, horizontal or inclined conveyor from the pit, a new bucket elevator and a new distributing screw conveyor.

C. SANTIAGO SILO PROBLEMS

The silos at Santiago have been a matter of concern because of the uneven settling which has occurred. Although the settling is uneven, the total amount of settling is not particularly large. One corner has settled about 15 centimeters. This is well within accepted limits. One elevator in Kansas settled approximately 60 centimeters and 30 centimeters is not unusual.

However, the problem is of concern and the following steps have or should be taken:

1. Four new soil borings have been made to an adequate depth.

2. A proposal by the soil engineers to install piling around the periphery has been made.

3. Soil data and the proposed piling will be checked by specialized engineers consulting for Kansas State University.

4. INESPRE has requested technical assistance from AID for an engineer to visit the site to advise on the foundation and some wall cracking problems.

5. Since the headhouse and silos were not on a common footing, a severe strain has been placed on conveyors and structural members connecting the two buildings. The following steps should be taken:

a. Provide temporary cable support braces to the bucket elevators.

b. Disconnect all spouting attached to the bucket elevators and silos at the point closest to the silo roof.

c. Disconnect all structural members which connect the two buildings. This probably should be done by disconnecting from the silos.

d. Replumb the elevators.

e. Reconnect the structural members and repair broken braces.

f. Reconnect the spouting.

6. As this facility has probably not reached its ultimate soil compaction, Step 5 may have to be repeated at a future time.

7. Horizontal and vertical cracks in the bin walls have occurred. These cracks should be V-ed out at least as deep as the reinforcing, caulked with a fiber caulking and the outer surface caulked with a suitable silicone or other caulking compound. (General Electric Company makes a suitable silicone caulking compound.)

8. If further study by a soil-structural engineer shows that steps might be feasible to raise the sunken end of the silos by pumping grout in under the existing foundation, the above steps might be delayed until the pumping is completed.

D. OTHER ELEVATOR VISITS

The Herrera Elevator was inspected briefly and some observations are:

1. Voltage problems, because of inadequate cables between the transformers and control room were reported. New larger cables should not be difficult to install.

2. The wiring in the motor control room is inadequate. All fuses and disconnect switches should be properly enclosed. Fuses should be replaced with Fusetrons. All electrical devices should be replaced where they are exposed.

3. There is excessive dust deposited in the motor control and dryer control rooms. This is a distinct fire hazard. These areas should be thoroughly cleaned.

4. Equipment maintenance is badly needed. This includes:

   a. Repair or replacement of screw conveyor troughs.

   b. Repair of spouting.

   c. Replacement of many V-belt drives with matched sets of belts.

5. The operating characteristics of the aeration fan should be checked to see if excessive operating expense is incurred when only a few bins are being aerated.

6. At least one bin discharge screw has excessive capacity. A new drive pulley to slow the screw should correct this.

The elevator at La Vega was visited. The following deficiencies were noted and discussed:

1. The Motomco moisture meter was reported out of order and this had been used to calibrate two other meters. The following procedure is recommended for all moisture meters:

a. Every facility should be equipped with two (preferably alike) moisture meters. A sample of grain should be tested in each meter each day to see that they agree. If the discrepency is more than 0.5 percent moisture, they should be checked against an oven moisture test.

2. The motor on the truck hoist was reported to have been out of service for over a year. This is further indication of too low a maintenance budget.

3. Electrical wiring changes have been made improperly. All electrical wiring should be in conduit. This wiring is a fire hazard.

4. An electrical welder was present in the building. The use of welders in grain storages is a fire hazard.

5. The facilities are not being kept clean. These dust deposits are a fire and explosion hazard and will serve as a harbor for insects.

Two other storage facilities were visited. One warehouse for bag rice storage was in excellent condition. The housekeeping was very good and there was no evidence of insects or rodents. Two refrigerated storages were visited.

One refrigerated storage has been used for onions. Problems were encountered with excessive frost formation on the coils. Recommendations will follow.

The other refrigerated storage was being used for beans. The use of refrigerated storage for beans must be quite expensive. Research should be conducted to see if beans can be dried to a lower moisture and kept in normal warehouses. Rewetting the beans a few days before they are to be sold might overcome the increased cooking time problem which was reported to occur with the drier beans. Since beans are so important a food item among low income groups, marketing costs should be kept as low as possible.

E. PROPOSED NEW PURCHASING CENTERS

Since the plans for the new marketing centers are very incomplete, only a few general remarks will be made.

These centers will need some storage space. Simple warehouses are probably all that is needed since most grains will probably be received in bags. If fertilizer and other inputs are to be stored, the warehouse would be adequate.

The warehouse should be constructed as cheaply as possible. Probably a 10 centimeter thick concrete floor on a 30 centimeter sand fill should be used if flooding is not a problem. Concrete block walls, steel roof trusses and cement asbestos, corrugated roofing would be used. A cost of 95 pesos/M^2 was estimated by one contractor. A 4 m high sidewall will allow about 1.5 tons of sacked rough rice per square meter of floor space and allow adequate aisle room.

Drying platforms for sun drying of rice would cost about 4 pesos/M^2.

PART II PROPOSED RURAL AGRICULTURAL MARKETING CENTERS

Many countries have found rural marketing centers to be of great value. Existing studies (SEA-IICA) of the marketing channels for various major products may indicate inefficiencies in the present marketing system which could be improved by better financed and managed rural marketing facilities where small farmers can obtain diverse marketing services. Also some countries (e.g. Colombia) have found commercial surplus above home consumption when a previously unserved area obtains a marketing outlet.

In most developed countries, marketing centers (such as grain purchasing centers) also provide farm inputs such as seed and fertilizer. This provides a better utilization of management talent, labor and other fixed cost items.

Experience in Colombia has lead to the use of INAGRARIO supply centers to purchase grain for IDEMA, the grain marketing agency. Tunisia has also combined sales of farm inputs with grain purchasing and the same warehouses used to store fertilizer are also used to store bagged grain at other times.

The physical form of a marketing center can vary. Costa Rica has trucks which go into the villages to buy grain and return it to a center where it is cleaned, dried and assembled into larger lots before further transport.

Ownership of marketing centers varies as to whether it is private, cooperative, or partially or wholly government owned. Government franchised and partially financed facilities might be possible alternatives.

A. GOALS AND OBJECTIVES OF THE PROPOSED CENTERS

The basic idea behind the proposed center is the improvement of the general well being of the farmer and subsequently increased production of those

agricultural products which compose the main staple items in the country. The following objectives have been suggested:

(1) Federal assistance at the rural level to achieve a more homogeneous production of crops by regions.

(2) Establish more efficient marketing channels to provide those basic products which compose the typical market basket of a rural farmer.

(3) Integrate selling points (tiendas de insumo) for agricultural inputs with rural marketing service centers.

(4) Establish an efficient marketing service at the farm level for agricultural products.

(5) Provide custom service to the farmers if so desired.

(6) Integrate rural marketing services with other available institutionalized services, such as production credit and agricultural extension.

B. COMMENTS REGARDING THE PROPOSED CENTERS AND RECOMMENDATIONS

1. Four different regions with contrasting characteristics have been proposed for the initial implementation of four "proto-types" of Rural Marketing Service Centers. These regions include (1) a predominantly rice growing region, (2) a region (Bani) which has a high degree of farmer organization but grows mainly vegetables, (3) El Cercado which includes more traditional farming (beans, batata, peanuts, yuca) but has little organization and (4) a region which grows mainly fruits and some rice and has little organization of production.

This approach is sound and highly commendable since, (1) due to the different crops grown in each region each Rural Marketing Service Center will have to be adapted to their specific requirements, (2) the different types and levels of crop production organization will influence the type of services

provided by the centers as well as the general characteristic of each, (3) the different level of infrastructure development within each region will influence location of the center within the region and maximum distance between the center and the farmer to be serviced.

In Colombia, for example, rural service centers were set up in the vicinity of subsistence farmers. One of the surprising results was the reduction of the cultivation of some crops and the increase of others. Clearly, this was due to the new opportunity the subsistence farmer found of selling his most profitable product. As a result, two things could be observed; increased production and increased homogeneity of agricultural products in that region.

Another possible impact could happen; over the long run a gradual change from risk minimization to resource and profit maximization could occur.

This proposed stratified implementation of "experimental" centers for Rural Marketing Services will provide a unique way of gathering further knowledge as to whether or not they are successful; this will lead to meaningful possible modifications on the concept and related functions.

2. The studies so far have focused more on identifying agricultural associations and number of members within these associations who could be clients of the proposed Rural Marketing Service Centers. It seems that "best" location and "minimum" size have been determined.

However, a key variable, namely expected volume of operation, has yet to be determined. This problem can be approached in two stages. First, a marketing flow survey (including sources--region or area of agricultural products and consumption data by area) at a macro level will help identify general logical locations of each center by region. As explained before, these four regions seemed to have been identified already. Second, the basic concept

behind the expected volume of operation within a selected region (and derived key variables as explained below) is the radius of influence of such a center. This radius, though difficult to predict, can be approximated with the guidelines provided in Appendix A. This concept is important in the sense that it will approximate the number of farmers that may be willing to participate in such a project from which the following key variables can be estimated which are relevant for the feasibility study:

(a) Approximate volume and type of agricultural products to be handled (rice, corn, beans, yuca, plantains, etc.)

(b) Approximate volume of inputs (seed, fertilizer, herbicides, insecticides, tools)

(c) Approximate most feasible location for the center

(d) Size of the center (size of warehouse, office, etc.)

(e) Approximate number of people needed to run the center

(f) Approximate number of trucks, pick-ups, and cars needed

(g) Approximate number and type of equipment and size (drying platform, drier, thresher, huller, etc.)

(h) Amount of credit needed by crop

(i) Other.

Therefore, it seems very important that the above observations should be taken into consideration in future "micro" research and analysis.

3. The quality and availability of roads as well as the means of transportation available will influence the radius of operation or area covered by such a marketing center. This in turn will influence the "transport equivalent,"

i.e., a farmer may prefer to transport 100 kgs. of corn in the form of a given number of chickens or eggs instead of the corn. Therefore, the distance to the center may influence the farmer's preference as to what kind of product to transport.

4. The coordination of these Rural Marketing Service Centers with the imput centers now being implemented should be seriously considered as one of the alternatives to avoid duplication of facilities, cost and effort.

5. These marketing centers may add a new link to the existing marketing system or they may eliminate one or more. The impact of these possibilities should be evaluated with respect to the efficiency and social function performed by these existing links.

6. Consideration should be given from where and from whom the center will obtain its inputs and to whom and where it will sell the agricultural outputs. It may change existing marketing links for inputs and outputs.

7. Consideration should be given to a possible combination of four basic activities, (a) supply of inputs (see point 4), (b) outputs outlet (proposed centers), (c) facilitating credit (being presently provided by the agricultural bank and private sources (e.g. rice millers), and (d) technical assistance (see point 8) including marketing extension agents.

For example, after many years of working independently, INAGRARIO and IDEMA (price stabilization group) in Colombia are beginning to coordinate their activities. INAGRARIO purchases for IDEMA and stores in IDEMA's central facilities for long-term storage. Such a system allows for coordination of transportation.

8. Since technical assistance is presently being provided in rural areas by agricultural extension agents from SEA, consideration should be given to complement this technical service,or vice versa,with the proposed services of the centers.

9. If it is going to be a permanent center, consideration should be given to potential changes (increase) in the radius of operation which will affect the volume, transportation, capacity, etc.

10. A survey and/or feasibility study should be executed for each particular area. The results of these surveys or feasibility studies will probably differ from one region to another, i.e., a generalized example for nationwide implementation should be avoided.

11. Considerable attention should be given to who is going to run these centers (government, franchised, private, half government-half private, farmers' association, coops, etc.)

12. The number of products to be handled in each center, in the early stages of the project, should be carefully analyzed.

C. CENTER FOR RURAL MARKETING SERVICES-FEASIBILITY STUDY

1. Economic Feasibility Study

In considering a Center for Rural Marketing Services for a given area for which relevant data has previously been gathered (proposed questionnaire, Appendix A), a feasibility study should be undertaken in order to determine the degree of feasibility and financial requirements.

The data requirements for measuring the economic feasibility of the proposed centers include:

- Schedule of capital cost for facilities, equipment, land, and other capital expense.
- Schedule of working capital requirements for inventories, accounts receivables, cash and other current assets.
- Schedule of projected revenue and income (benefits)
- Schedule of projected operating costs.

The primary objective of feasibility analysis is to measure the economic potential of the prototype, normally measured as the projected rate of return on capital investment. The principal measure of economic soundness used in the feasibility analysis is the potential annual rate of return on investment and on the same flow of money into and out of the enterprise. The following is a brief guideline for completing such a feasibility study:

a. Radius of operation

Within the approximated radius of operation, both the number of farmers expected to participate in the estimated volume of operation and relevant key variables necessary for a feasibility analysis can be determined (see point number 2 in previous section).

b. Facilities and equipment

Depending on the volume of operation and estimated convergence point of agricultural outputs, size and "best" location of the center can be approximated. The questionnaire (Appendix 1) will also determine the size of the facility and number of equipment such as trucks, pick-ups, dryers (platform or mechanical), threshers, hullers, etc.

Cost estimates for land, site preparation, and construction can be obtained from a consulting engineer and other sources. Equipment outlays can be obtained from suppliers.

c. Working Capital Requirements for Current Assets

The amount of working capital needed should be estimated on a monthly basis for each agricultural input and output, as well as other items. These include:

- inventory of agricultural inputs
- inventory of agricultural outputs
- finished goods inventory
- net accounts receivables
- cash balance
- prepaid expenses (insurance)
- other.

d. Gross Revenue from Sales, Cost of Sales, and Other Income

A schedule for gross revenue for each product can be obtained by multiplying expected sales volume times price, while cost of goods sold are derived in a similar manner. Other income includes such items as custom services and by-product sales.

Sales revenue is derived by subtracting Cost of Sales from Gross Revenue, and finally, Net Revenue is obtained by subtracting operating costs.

e. Operating Costs

Total annual variable and fixed operating costs are based on the expected volume of operation and services rendered. Major costs to be considered are:

(1) Variable Costs

-direct wages

-fuel and power costs

-repair and maintenance

-supplies and materials

-interest

-miscellaneous

-other.

(2) Fixed Costs

-administration salaries

-office costs

-depreciation

-taxes

-insurance

-interest

-other.

(3) Total Costs

Total costs should be calculated on a per unit basis such as, total cost per unit of rough rice and total cost per month.

A summary table containing these items is constructed for the purpose of feasibility analysis. The economic potential for the center under study is determined by comparing the rate of return obtained with the relevant opportunity cost of capital.

2. Developing Pro Forma Financial Statements

The pro forma financial statements follow the principles and format of standard accounting statements, including (1) the operating statements, (2) the source and application of funds, and (3) the balance accounts of income, expenses and net income over a series of specific periods of time.

The balance statements include the "fund" accounts of assets, liabilities and net worth at discreet points of time in the future. The source and application of funds show the flow of cash funds by period, including the periods in the operating statement, and indicates the net change in the balance sheet accounts from the end of one period to the end of the next.

The pro forma financial statements are used to work out and test a sound and practical plan for the centers, and to indicate the outcome of the plan to potential lending institutions.

The economic cash flow schedules from the feasibility analysis provide the basic data for developing the pro forma statements. The additional information to be reflected in these statements includes (1) depreciation schedules for buildings, equipment and machinery, (2) available equity capital, (3) probable periodic withdrawals of earnings, (4) income tax schedules, and (5) probable interest rates, repayment schedules and the terms of financing for long-term and short-term loans.

The proposed project of centers for rural marketing services has a lot of potential and promise. The work done so far towards their implementation has been well executed and is in the proper direction.

In case it is needed, Kansas State University will be more than happy to provide further assistance in this matter.

3. Basic Data Requirements for the Evaluation of Installed Grain Storage Capacity and Future Expansion

In order to evaluate the installed grain storage capacity and projections of future expansion of these facilities, certain basic data will be required.

The following is a list of the basic data requirements.

a. Projected consumption and production potentials

(1) Monthly consumption survey data for all grains

(a) Rural

-rural per capita consumption

-rural population

-rural seasonal consumption patterns

(b) Urban

-urban per capita consumption

-urban population

-urban seasonal consumption patterns

(2) Monthly production survey data

(a) Wet season harvest pattern

-hectares by class of crop

-yield by class

(b) Dry season harvest pattern

-hectares by class of crop

-yields by class of crop.

b. Monthly marketing data

(1) Transport links and distances between links

-key highway transport links and distances

-key rail transport links and distances

-key river transport links and distances

-key coastal transport links and distances

(2) Transport volume

-volume transported between highway links and modes

-volume transported between rail links

-volume transported between river links

-volume transported between coastal links

(3) Cost of transportation

-transport cost between highway links and mode

-transport cost between rail links

-transport cost between river links

-transport cost between coastal links.

c. Storage and processing capacities

(1) Storage capacity

-existing storage capacity and locations

-future (already planned and under construction) storage capacity

(2) Processing capacity

-existing processing capacity

-future (already planned and under construction) processing capacity.

The above is a brief summary of the data requirements. For methods of survey and methodology of gathering this data refer to Volumes I and II of "User's Guide to Computerized System for Feasible Agribusiness Development," Food and Feed Grain Institute, Kansas State University. These two volumes are available at the USAID Mission in Santo Domingo.

APPENDIX I

PROPOSED GUIDELINE FOR A STRUCTURED SURVEY QUESTIONNAIRE

The following is a basic guideline which could serve in the formulation of a structural survey questionnaire. The basic objectives of such a questionnaire include (1) establishing degree of desirability of a center for rural marketing services, (2) approximating radius of operation for such a center, (3) estimating expected volume of operation (inputs, outputs, credit), (4) obtaining relevant data for a feasibility analysis, (5) obtaining a thorough knowledge with respect to the existing situation at the farm level.

A. Desirability of a Center for Rural Marketing Services

1a. Do you know what a Center for Rural Marketing Services is?

Yes or No

2a. If yes, would you like to be associated with one? Yes or No

3a. If no, explain what such a center means and ask question 2a.

Yes or No

4a. Why would you like to have such a center? What would be the advantages? Get the farmer's opinion.

5a. Why wouldn't you like to have such a center? What would be the disadvantages? Get the farmer's opinion.

The above questions will clarify (1) the knowledge of the farmer about the functions of such a center, (2) how many would like to have one, (3) how many would not like to have one, (4) expected number of farmers willing to participate, (5) expected action radius, (6) expected volume of operation (inputs, outputs, credit, etc.), obtained from the remaining questions.

B. Required Agricultural Inputs

1b. What kind of inputs do you purchase?

-fertilizer(s)

-seed(s)

-insecticide(s)

-herbicide(s)

-tool(s)

-other(s).

2b. How much of each input do you purchase?

3b. How much do you pay for each (price per unit)?

4b. Where do you purchase each input?

-local grocery store?

-hardware store?

-specialized store?

-government store?

-general store?

-buyer of output?

5b. When do you buy each input?

-immediately before planting?

-long before planting?

-any other time?

6b. Are all the inputs you need available on a timely basis?

7b. Do you produce any of your inputs yourself?

Questions 3b and 4b will give you an idea about margins in order to be competitive.

C. Agricultural Outputs

1c. What kind of agricultural products do you produce? (Rice, corn, beans, plaintains, yuca, etc.)

2c. What kind of agricultural products do you sell?

3c. How much of each?

4c. To whom? Why?

5c. At what price?

-"official price"?

-discount of premium?

6c. When do you sell? Why?

7c. Do you keep some for your own consumption?

-how much?

-why?

8c. When you sell how is the quality of your product determined? (Explain procedure.)

9c. How long and when is the harvest for each crop?

10c. How many crops per year? Why?

11c. If it rains do you interrupt your harvest? If yes, for how long?

12c. How much is lost of each crop due to lack of timely inputs, farming practices, storage, etc.?

D. Farming Practices

The following questions are related to the actual farm practices used. They will be different by crop, region, and type of farmer. Therefore, the following questions are of a general nature and should be tailored to the regions, crop, and farmer when formulating the interview questionnaire.

1d. How do you prepare your land before planting? How long does it take?

2d. How do you plant? How long does it take per unit of area cultivated?

3d. What are your practices during the growing season?

-upkeep of the crop?

-irrigation procedures?

-herbicide application?

-insecticide application?

-weeding?

-other?

How long is the growing season?

4d. How do you harvest? How long does it last?

Questions 1d through 4d should also answer the kind of power a farmer uses (human, animal, mechanical) and how much the type of power he uses costs him.

5d. Do you use the "slash-burn" method? If yes, how long (years) do you use one parcel of land before you slash and burn another?

E. Transportation of Agricultural Outputs

1e. How is each product transported?

-mode?

-what kind of container or packing material do you use?

-Is each crop transported separately or two or more crops together?

-Is each farmer's crop transported separately or do you join other farmers for transportation?

2e. How far do you transport? From where to where?

3e. How long does it take to transport the good(s)?

4e. How much does it cost for each good?

5e. Do you provide your own transportation?

6e. Do you hire transportation?

7e. Does the buyer come to you in his vehicle?

8e. When do you transport each crop (Time of day)?

9e. When do you transport each crop after the harvest?

F. Credit

1f. For what purpose do you use credit?

-agricultural production?

-own consumption?

-party?

-medical requirements?

-other?

2f. From whom do you obtain your credit?

3f. Why do you use this credit source?

4f. Do you get all the credit you need for your agricultural inputs from "that" source? What happens if you don't?

5f. How much credit do you get for each crop?

6f. Do you get your credit in one lump sum or in time intervals?

7f. What rate of interest is charged by each source?

8f. What kind of contract do you use?

-written?

-oral?

-other?

9f. For how long do you take credit?

-days?

-weeks?

-months?

10f. When do you pay back your credit?

-immediately after harvest?

-some other time?

11f. What happens if you cannot pay your credit back?

G. Technical Assistance

1g. Source of technical assistance:

-extension agent?

-agricultural engineer by region?

-private?

-intermediary?

-neighbor?

-radio? What time of broadcast? Does farmer or his wife listen regularly?

2g. What kind of information do you get by source and do you get enough or any new information about each agricultural input, improved farming practices, and outputs (prices)? How often?

3g. Is this information good and easy to understand?

4g. If you get information, do you get it in time to make necessary changes?

5g. What other technical services are offered?

-land improvement and conservation?

-soil tests

-etc.

H. Labor Input

1h. Do you work alone or do your family members work with you?

2h. Do you have to hire extra labor during the year and is it difficult to get?

3h. If yes,

-how long do they work for you?

-what kind of work do they do for you?

-how much do you pay them?

-are they experienced, i.e., do you get good help?

4h. Do you hire yourself out sometime during the year? If yes,

-for how long?

-for whom do you work?

-what kind of work do you do?

-how much do you earn (per day, per week, per month, total)

I. Probable Custom Services that could be provided by the Center

I. Drying

1i. Do you dry your own crop(s) at home?

2i. If yes, what kind of facility do you have and how do you do it? Explain procedure.

-how much do you dry?

-how many times do you turn over the crop (assuming sun drying)?

-do you cover the crop during the night or do you store it; if so, where?

-do you cover the crop when it rains while you are drying it?

-how long does it take to dry?

-etc.

3i. If no, why not?

4i. Does somebody else dry your crop? Who? Why?

5i. If you could make a good profit (increase your revenue) by drying your crop at home, i.e., if you had the facility or if you could build one (cement floor, tarpaulin, sacks sewn together) is there any other reason why you still could not dry your crop before selling it?

6i. Would it be of interest to you to have a drying facility available (community drying platforms, small dryer provided by the

center) if you would get a better price for your product?

7i. How much would you be willing to pay for this service?

II. Threshing and Hulling

The questions about threshing and hulling follow the same format as those for drying. Again, the key questions are:

-do you thresh and/or hull?

-if yes, explain procedure.

-if no, why not?

-would you like to have such a service provided if you can get a better price?

J. Control information about Farmer

I. Food Consumption

General food consumption habits and patterns should be gathered. For example,

-do you keep rice for your own home consumption?

-how much rice do you consume at home (per month, per year)?

-do you prefer brown or white rice?

-If you buy your rice

-do you buy brown rice?

-do you buy white rice?

-how much?

-where (miller, retail)?

-how much do you pay?

II. Farm

1. Size of farm

2. Tenure status

3. Crop enterprises (areas harvested)

4. Livestock enterprises (number)

III. Family

1. Age of family head

2. Family size

3. Sons by age

4. Daughters by age

IV. Location

1. Number of parcels in farm

2. Location of main parcel

a. Distance to main road

b. Distance to village (_____)
name

c. Distance to main center (_____)
name

3. Location of other parcels

(as 2 above)

It is recommended that the above guidelines should be used to construct a simple and easy-to-use questionnaire in order to gather this required information. Since some of the questions stated here have been analyzed by Mr. Pla and others, no difficulty arises in filling them in. However, if the information already available for some of the questions is too general in nature, new information should be gathered.

It is also recommended that for each farmer interviewed, one questionnaire should be filled out. Once enough farmers have been interviewed, then based on the Yes or No answers within a potentially feasible radius of action and volume, a-correlation analysis can be made to find out the degree (%) of desirability of such centers and a final feasibility analysis can be conducted.

PART III RENOVATION OF STORAGE AND HANDLING FACILITIES AT SANTIAGO

A. FACILITY DESCRIPTION

The facility consists of a storage unit and an adjacent headhouse The storage unit was constructed of reinforced concrete throughout and contains 15 round tanks (five in one row in the north to south direction[1/] and three wide one of 4.96 meter (16 feet-3 inches) inside diameter and rise 75 feet, 6 inches from a mat foundation to a roof slab). The round tanks are spread 1.5 meters (4 feet -11 inches) in the north to south direction and 1.0 meter (3 feet -3 inches) in the east to west direction providing eight interstice bins.

The thickness of round walls was measured at 8 inches (engineering drawing shows 7 inches as requirement). Several intermediate straight walls were measured as 7 inches. Bin bottoms for the round tanks consist of an 8-inch slab sloped at 40° with respect to the horizon which is supported by an edge beam, columns, and walls to the mat foundation. Bin bottoms for the interstice bins were made by constructing a slab sloping two directions on the center line of bins supported by funnel walls and adjacent sloping slabs. Bin bottoms were modified in 1972-73 for more thorough unloading by adding concrete fill over portions of existing bottoms.

1/ For the purpose of this report, the direction north shall be considered as towards the existing "almancens" when standing inside the grain elevator.

All round tank walls were constructed by the slipform method and all bin bottoms were poured-in-place, conventionally-formed concrete. The entire storage complex rests on a 3-foot-thick mattress foundation slab which measures 110.6 feet by 62.7 feet. The top of the mat is located approximately 2 inches below existing grade. A finished topping was added over all exposed areas of the mat.

The entire dead weight of the storage unit was calculated by the consultant to be 13,177,000 pounds including bin bottom modifications, equipment, etc. The storage capacity of the entire complex was calculated to be 282,800 cubic feet. In addition, a 7 percent grain compaction would result in an actual capacity of 302,600 cubic feet.

The gross pressure exerted on the soil, if loaded to the above capacities with rice weighing 38 pounds per cubic foot or corn weighing 48 pounds per cubic foot, would be 3,500 pounds per square foot and 4,000 pounds per square foot, respectively.

The storage unit is discharged by four (4) screw conveyors. Each conveyor is centered under two interstice bins, i.e. one between each set of three round tanks and all flow easterly. The two center conveyors enter the headhouse directly, approximately 3 feet from the north and south walls. The outside two conveyors both discharge to another screw conveyor which then flows both north and south respectively to the boot pit of the headhouse. The four discharge conveyors are mounted at and to the top of the mat foundation and, therefore, the bottom of the screw housing (trough) were partially imbedded in the topping over the mat. Since these

conveyors are so located in elevation, the two perpendicular conveyors accepting grain from the north and south discharge conveyors had to be placed below grade and are mounted in concrete troughs open at the top.

A grain drier was placed adjacent to the north exterior headhouse wall and its westerly foundation edge is located approximately 11 feet from the east edge of the storage mat foundation; therefore, allowing room for installation of the north concrete trough carrying the north below-grade conveyor. The north end of this trough turns east and is connected to the drier foundation approximately 5 feet from the north end of the drier foundation. The drier column, i.e. main weight on the drier structure, is located on the south end of the drier foundation.

The headhouse unit is a conventionally constructed, structural concrete column, beam and slab building with concrete block infill between columns to form the exterior walls. It has two stories above ground and a basement framed in concrete walls. The west exterior wall of the headhouse is 6 feet east of the storage units foundation, is 29 feet -6 inches wide north and south, and centered with respect to the grain elevator i.e. the 29 feet -6 inch dimension is centered on the 110.6 feet mat dimensions. The basement forms the boot pit for three main bucket elevators.

These three bucket elevators rise to a height of approximately 30 feet above the roof of the storage unit. A caged manlift is located between the bucket elevators and the storage unit. The manlift rises only to the roof of the storage unit. Below the headhouse roof, structural steel

channels are framed and bolt connected (semi-rigid) to both the headhouse wall and the storage unit wall supporting the manlift on its north and south sides. Above the headhouse roof, similar channels are framed from the bucket elevator group to the storage unit walls. The bucket elevator group also has certain light horizontal framing tying the group together above the headhouse roof. The group is braced at the top with four cables connected to the storage and headhouse roofs.

In the original design, a sump was located at the southwest corner outside the headhouse. As constructed, it has a 3 feet inside diameter by 11 feet below-grade tube with a concrete base. The tube only has one connection to a floor drain in the southwest corner of the headhouse basement and one to the south conveyor trough to the consultant's knowledge. Ground water easily enters the sump. Original drawings indicate clay tile drainage required around the top of the headhouse foundation and the top of the mat foundation, all discharging to the sump. A sump pump and discharge line was specified and installed in the sump.

Originally, the immediate site, excluding east of storage mat foundation, was asphalt paved and the top of the asphalt was flush with the final topping over the mat foundation. Surface drainage was not satisfactory and; therefore, in 1973 a concrete trough with cast iron grating top was established on the north and west sides of the mat foundation and the asphalt paving was replaced with concrete. The south side of the mat has good natural slope away from the mat. No paving has ever been in place east of the mat.

The Yaque river flowing through Santiago is approximately 600 feet in distance from the plant and an estimated 75 feet lower than the site. Reportedly, the ground water level rises and falls with the river level throughout the year.

B. LOADING HISTORY OF STORAGE UNIT

As stated previously, the construction was finished in approximately May of 1969. Reportedly, the storage unit was first loaded in mid-1970 with rough rice (unhulled) which weighs approximately 38 pounds per cubic foot and maintained almost full during late 1970 and 1971. No actual loading records were observed but conversations with Señor Martinez, an INESPRE employee who has been on this site essentially since the first loadings, revealed that probably up to 100,000 quintales (10,000,000 pounds) of rough rice had been stored at some period. By the consultant's calculations, no more than 11,500,000 pounds of rough rice could be stored in this facility; therefore, 100,000 quintales represents a unit - 87 percent full. More than likely, the unit was maintained more like 70 percent full up through 1971 since this represents a more reasonable figure for this type of facility. At this figure, the load averaged 8,000,000 pounds.

During 1972 and 1973 the bin bottoms were being modified and it is most reasonable to assume the average load at less than 70 percent.

In late 1973 the unit was loaded for the first time with corn weighing approximately 48 pounds per cubic foot. By the consultant's calculations, no more than 14,500,000 pounds of corn could be stored in this facility. Reportedly, about 10,000,000 pounds of corn was in storage in December of 1973. If, at worst, the house was full of corn compared to an assumed 70 percent load of rice, the difference would be 14,500,000 pounds less 8,000,000 pounds or 6,500,000 pounds. Translating this possible worst condition to gross foundation pressure, the increase would be approximately 33 percent.

Sometime in December of 1973, Señor Martinez noticed the storage unit discharge conveyors rising out of the mat topping and the skewing of manlift support members. An investigation was begun. Bolts were established on several points of the storage wall to observe the settlement. According to Señor Martinez, the structure appeared to stabilize except for the northeast corner. Accordingly, unloading was begun on that corner in January, 1974.

The consultant is in receipt of a report dated December 1974 of the Laboratorio de Ingeniera (S-380) wherein logs of four new soil investigation holes are noted, an analysis of the soil problems is presented, and level readings of the bolt points during unloading are given from January 19 through April 13, 1974, and a suggested solution using piling has been presented. The new borings were made in September of 1974 and the ground water table was approximately 8 feet below grade.

The storage facility has essentially been empty since April 1974. The level readings during unloading show a rise of approximately ½ inch on the east side compared to slightly less than ¼ inch on the west side from a loaded to an unloaded condition indicating a slight, but insignificant, tendency to tilt towards the east.

C. INVESTIGATIONS AND FACILITY DISTRESS

At first observation at the east side of the storage unit, one sees the horizontal structural steel framing members supporting the manlift skewed upwards at the headhouse wall and downwards at the storage wall connection. The bucket elevators appear plumb from the bottom upwards to an elevation approximately at the storage unit roof line. At the storage roof elevation, they began to lean to the west.

The storage unit discharge screws have been bent upwards at their discharge ends and the bottoms of sheet metal enclosures (trough) have been raised out of the concrete topping over the mat foundation. Beginning at the south conveyor, the southern-most two conveyors appear to have been raised approximately the same amount (±1½ inches), the third one from the south slightly more raised (±2½ inches) and the northern-most even more (±4 inches).

The mat foundation, at first observation, appears to have settled increasingly on this east side from a minimum on the southeast corner to a maximum on the northeast corner. It was discovered that the northern conveyor was actually raised upward plus or minus 2.5 inches by the action of the drier foundation. As previously described, the main weight of the drier column was adjacent to the north headhouse wall (most assuredly over some backfill). It was observed that the drier foundation did not crack but sustained its monolithicity, rotated, and thereby lifted up its north end and, consequently, the north conveyor.

A horizontal exterior wall crack in the storage unit exists on the five southern tanks located approximately 15 feet from the roof line. It was reached by means of a boson's chair rig and observed to vary between 1/32 inch and 1/16 inch. This crack reportedly follows a cold joint line and is not considered to be potentially dangerous.

The storage unit's roof slab was observed to be without any major cracking that would indicate differential settlement. Several tanks and interstices were inspected by a drop cord through roof manholes. No evidence of spread walls separating from round tanks was observed. Evidence of water entering the southeast tank through the aforementioned horizontal wall crack was observed.

Storage mat foundation settlement was difficult to measure at the edges of the mat due to the modified paving conditions surrounding it. However, where the topping over the mat tended to "span" from the drainage trough to the storage walls (north side primarily) it was broken out and the hollow depth between the bottom of the topping and the top of the original mat was measured at $\pm 2\frac{1}{2}$ inches. Soundings taken on top of the mat topping at <u>all</u> points around the mat and through the tunnels resounded with a hollow note indicating no bond between topping and original mat or an actual separation as noted on the north.

The most positive indication of foundation settlement came from measuring the difference in elevation of the ends of the horizontal steel members supporting the manlift between headhouse and storage unit. Assuming the members were installed originally in a horizontal poisiton, the settlement indicated was 4 inches. One might logically ask if some of this 4 inches did not appear due to possible tilting of the top of the unit to the east.

This is entirely possible and even more probable due to the fact that some original soil along the eastern edge had to be originally removed and replaced in order to construct the basement in the headhouse and contractors are famous for replacing fill without proper compaction. However, while some tilting may have taken place, it had to be minor as no clear pushing of horizontal members connecting the roof of the headhouse to the storage unit was evident but the same vertical displacement of ends is clear. Other evidence to be shown also does not clearly support significant tilting to the east.

It should be noted that the probability that the headhouse was raised by hydrostatic pressure was also investigated. Rough calculations indicate sufficient weight in headhouse construction to have prevented this possibility and, furthermore, the basement connection to the sump historically filled the basement with ground water.

Due to the fact that the original mat foundation was not screeded and finished, no level circuit could reasonably be run on it and interpreted with much confidence; however, a level circuit was run on the bottom of the roof slab. Unfortunately, no clear indication of settlement pattern was really obtained from this either. Certain readings on the east side were the same as certain readings on the west side. The average of all readings on the west were 2 inches higher than the average of all readings on the east but this is believed to be all construction difference and cannot logically be interpreted as an indication of uniform or tilted settlement. Readings on the south side were only 1 centimeter different from the north side.

A significant indication of settlement pattern was obtained by dropping plumb bobs on two locations on the east and west sides and one

location on the north and south sides. Points were opposite each other on opposite sides of the storage unit. The south set, points A and B on attached drawing indicating east-west tilt, showed point A on the west with the top tilting 2 1/8 inches to the east but its opposite, point B was plumb. The north set, points C and D, showed top tilt of 3/8 inch west at C and 2 inches east on point D. Point E on the south end showed a top tilt of 3/8 inch toward the north end, point F on the north end showed 2½ inches top tilt to the north. There is no question in the consultant 's mind that these differences in out-of-plumb are construction errors that would commonly be found in this kind of structure.

Before December 1973, the headhouse basement took in water through the basement drain from the outside sump at several times during the year. Reportedly, the water level rose to a depth of 3 to 4 feet which completely inundated the bucket elevator bottoms rendering them inoperational. The sump pump could eventually draw down the basement water but night-time failure of electricity allowed the basement to refill. In December of 1974, during the settlement investigation, the sump pump was removed and the basement drain to the sump was sealed. The ground water level at the time of this investigation was 6 feet 6 inches below grade and, therefore, 1 foot 6 inches above the top of the basement floor and leaked through the basement floor and walls.

Annual rainfall in Santiago averages approximately 40 inches. Exact amounts from 1971 through 1975 varied between a high of 46 inches to a low of 36 inches, respectively.

The soil report (S-380) clearly defines a soil layer immediately under the foundation mat throughout the mat area that contains soils with unconfined

compressive strengths which indicate possible ultimate bearing valves less than the maximum 4000 lb./sq.ft. that could be imposed by the storage unit. This consultant is not knowledgeable enough in the soil discipline to determine if a bearing failure (possible extreme tipping of the storage unit) could take place and, therefore, sought the advice of Woodward-Clyde Consultants of Kansas City, Mo.(see letter in Appendix).

A fluctuating ground water level can often times lower the shear strength of the soil and contribute to possible bearing failures and/or unit settlement. On site, the possibility of establishing a gravity drain to intercept the ground water table and alleviate the inundation of the headhouse at the same time was investigated. It was determined that the gravity drain was mostly possible but expensive. It's evaluation to lower the ground water table without later severe soil shrinkage and consequent rapid settlement was also a question for the soil experts.

D. CONCLUSIONS AND RECOMMENDATIONS

The storage unit's basic structural elements are considered safe and sound. The aforementioned horizontal crack appearing on the south five tank walls needs no structural treatment. It can be treated to prevent water entry to tanks in several fashions. The most permanent method would be to "V" the crack with a stone grinder, pack with okum and caulk with "Thiokol" - class A, type I as manufactured by the Thiokol Chemical Corp., P.O. Box 1296, Trenton, New Jersey 08607 or Silicone Sealant (SCS 1620) as manufactured by the General Electric Co., Silicone Product Department, Waterford, New York 12188. The next best method would be to trowel on a 3-inch high band of Bitumastic 50 and paint on a coating of Bituplastic 28 sealer over the mastic - both of which are manufactured by the Koppers Co. Inc., Koppers Building, Pittsburg, PA 15219. A less permanent method could be to paint on an elastometric paint such as a SCOTCH CLAD coating as manufactured by the 3M Company, 3M Center, St. Paul, Minnesota 55101. Probably the most effective and easiest method would be to use the Bitumastic material but the resultant black color may be offensive architectually. All other cracks observed in the various structural elements appear to be of no consequence.

Settlement of the storage unit undoubtedly started with it's very first loading. The actual total amount of settlement was probably about 1 inch (plus) from initial loading until December of 1973. This amount could easily have been overlooked by maintainence personnel. This Consultant is convinced that up to approximately an additional 2 inches did,

in fact, take place rather rapidly during the corn loading in November-December of 1973. Whether or not the foundation pressure was increased by 33 percent as has been shown as a possibility, is not too important as the direction of increased loading is well established and the compressible soil was obviously there and loaded to a unit valve that it is known could cause the settlement, i.e. this rapid settlement was no surprise.

Consultation with Woodward-Clyde has convinced this consultant that to reload the storage unit without any underpinning of any kind (including grout injection) or general foundation drainage is the only reasonable course of action. The observed history of loading coupled with the assurance from Woodward-Clyde that the low shear strength soils will not cause a bearing failure, has provided 99 percent assurance of future success. It has been well established that the unit did settle uniformly. Only differential settlement can structurally hurt this facility and the future risk of that occurring is minimal; however, the cost of monitoring the future settlement is also minimal and is highly recommend to provide T.H.E.S.P. R.E. the insurance they need to proceed with confidence. After all items of repair are made, it is recommended that the structure be reloaded, initially in uniform layers of one third of the total capacity, and preferably with corn. And that a level circuit of all established bolt points be made before any loading and after each one-third increment. It is desirable to leave the facility loaded at least 1 month or until the rate of settlement has decreased to less than one and one half (1½) millimeters per month. If differential settlement does become apparent at this end of any set of

reading, the opportunity to adjust the load to cause uniform settlement should immediately be undertaken. After this initial period and until a total of 2 additional inches of settlement has taken place in a uniform fashion, it is recommended that the facility be used normally and a level circuit (with load data on each bin) be made on a monthly basis. All of the above should be accomplished under the supervision of a competent structural engineer. In the unlikely event that differential settlement does take place, a program of soil stablization by grouting should be instituted.

Woodward-Clyde's opinion is that the proposed foundation drain around the mat foundation will not significantly lower the ground water level and that, in this soil, the fluctuating ground water table will not change settlement charteristics; therefore, happily no exterior mat drain is recommended. It is recommended, however, that the drain line from the headhouse basement be reconnected to the sump and that the bottom of the sump be drained by gravity to daylight or existing storm sewer. If this gravity drain is established, it should be done in a fashion that will <u>not</u> disturb the existing storage unit mat foundation. An alternate to the gravity drain could be an adequate sump pump with <u>automatic</u> cut in to alternate power in the event of normal line failure.

Site paving of the east side of the storage unit is recommended and, after some additional settlement has taken place, additional topping over the mat foundation on the north side to prevent trapping surface water would be desirable. Also, this Consultant highly recommends that the electrical circuit presently buried in the mat foundation topping be removed and relocated such that it will not be destroyed by any future settlement.

The manlift supports, bucket elevators, and discharge screw conveyors have been damaged essentially by vertical settlement of the storage unit. Additional vertical settlement will probably take place, therefore, the various elements need to be separated and/or jointed. Only a vast and economically unfeasible program of underpinning throughout the entire foundation area could prevent future settlement. No accurate estimate of final settlement has been made and, while it could be attempted, the cost could not be justified from a practical stand point. It is this Consultant's opinion that designers should consider that a minimum of 3 inches and a possible maximum of 6 inches of additional settlement will take place over the life of this facility. It is recommended that the bucket elevators be separated entirely from the manlift supports, that they be banded with structural steel angles or other members that make them an independent column braced by the headhouse building and by top cables. The manlift horizontal supports should be disconnected from not only the bucket elevators, but also the headhouse building. It is suggested that the manlift be supported by hanging it from the storage unit walls and providing adequate lateral support. These two items of renovation should be designed by a competent structural engineer. Further details of jointing the top bucket elevator spouts etc. need close attention. The discharge screw conveyors should be released on their east ends. The two center conveyors are presently grouted rigidly to the west headhouse foundation wall. They not only need to be freed from that grip but also provided with a slip joint at their final discharge point to the bucket elevators. The north and south discharge screw conveyors need to have a flexible support at the

concrete troughs and a slip joint connection to the perpendicular conveyors. The flexible support at the concrete troughs could be composed of styrofoam or neoprene shims between the concrete and the bottom of the conveyor coupled with an over-the-conveyor strap which could be easily adjusted as settlement occurs. Provisions for a possible 3 to 6 inches of additional settlement should be made throughout.

APPENDIX III

WOODWARD-CLYDE CONSULTANTS

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Phone 816 363 3663

April 30, 1976
WCC Project K76-34

Donald S. Jack & Assoc.
Structural Engineers
730 TenMain Center
920 Main Street
Kansas City, Missouri 64105

EXAMINATION OF REMEDIAL ALTERNATIVES
GRAIN STORAGE FACILITY
DOMINICAN REPUBLIC

Gentlemen:

In response to your request, we confirm opinions provided to you during several conferences regarding the appropriateness of remedial measures under consideration for the existing Grain Storage Facilities at Santiago in the Dominican Republic. It is our understanding these facilities were built in the late 1960's (1967-69), were loaded and operated for several years with rice in storage and, subsequently in approximately 1974 after being loaded with a similar but perhaps somewhat larger total weight of corn, had settled sufficiently that additional operation was suspended. You provided for our information a foundation investigation completed by others, subsequent to the settlement, and only recently the initial investigation completed prior to the grain storage facility construction. The report completed following the settlement recommended construction of a system of underpinning piles located outside the periphery of the existing silo mat.

The facility undergoing the settlement distress is a group of fifteen silos each 15 ft in diameter, located five in a row with three rows on an approximate 50 ft by 100 ft reinforced 3-ft thick concrete mat. The mat was established on what is believed to be natural soils below a thin thickness of fill which was removed prior to the mat construction. The best information available suggests a thin, somewhat irregular thickness of firm to low range stiff clay, subsequently underlain by more stiff materials for the entire depth of concern. The thickness of the potentially compressible soils is indicated to be in a range of from 2 to perhaps as much as 5 ft. The unconfined compressive strength of these materials ranges from a low of approximately 1 ksf to

as high as 2 ksf. Your observations during your recent visit to the site indicated a fluctuating groundwater table can and does occur. At the time of your visit it was close to the bottom of the concrete mat. Difficulty is being encountered in maintaining a dry boot pit and the existing sump facility has been abandoned due to poor continuity of electrical power. Furthermore, your observations have indicated that the silo group at the present time has settled approximately 4 in. according to the best indications of movements relative to the adjacent existing facilities and that no general trend to tipping or extensive differential movement is apparent. The single indication of structural distress, which is believed partially dependent on the construction of a "cold joint" is present in a 1/16-in. horizontal crack occurring close to the top of segments of several silos. Plumb bob measurements and level readings confirm, in your opinion, that the silos are settled relatively uniformly. Distortions are present between transfer auger housings which are tied, with no allowance for movement, to both the structure slab and adjacent off-mat facilities.

The following are our findings and recommendations based on the information presently available:

1. The settlment observed to date is a result of consolidation, and perhaps as modified by shear strains and concentrated lateral flow in the upper soft soil layers. Movements of the magnitude believed to have occurred are predictable with the soil properties and stress ranges and soil thicknesses.

2. With the exception of the relatively thin, irregular firm to stiff soil layer which closely underlies the mat, no significant thicknesses of material are present which upon loading to the proposed ranges would undergo important volume changes. Cyclic overstressing of the thin, firm to stiff soil layer will result in some additional shear strain but, in our opinion, strain of this type will not result in danger to the facility. It likely will result in the tendency for some additional movement with each cycle of loading.

3. Confinement of the thin, relatively softer layer would be desirable and could be considered, however, practical difficulties of effecting such confinement limit the desirability of such an approach. Furthermore, the knowledge that some additional settlement will occur regardless, and in the light of the already stressed condition due to past usage, confinement is unnecessary for safety. We recognize that construction could cause serious localized problems, and in any event would be costly.

4. With the soil types identified, modification of the local groundwater table beneath the slab and in the surrounding area will not enhance the stability factor nor significantly modify the amount of settlement which can be expected to occur during the succeeding years of the operations.

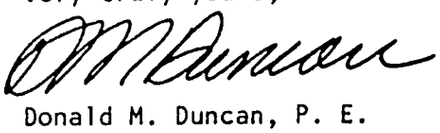
5. We recommend first consideration be given to modifying all the machinery mounts to allow for adjustment when expected additional movement occurs during the succeeding loading sequences. We recommend the silos be loaded in a uniform fashion, i.e. each of the fifteen silos be loaded in increments of approximately 5 ft to 10 ft maximum and that survey observations be made during the period of load increases. The data generated by these observations should be correlated for at least 6 points around the building periphery and 2 points within the silo clusters by plotting settlement for any given load increment against time, and plotting settlement versus the total imposed stress as the stress is increased. Depending on the information obtained by these readings, it could be desirable to modify the next load increment to obtain the best control of settlement and minimize potential differential movement to the greatest degree possible. Also, it could be desirable to modify the rate of additional storage to allow for stabilization under a given load increment.

6. A safe, adequate underpinning scheme utilizing any known design alternative would be prohibitively expensive. Of more importance, a less thorough underpinning method could result in extreme tendencies to differential movement and possibly severe distress of the superstructure. It is our opinion, based on our experience, that structures of the type under consideration can undergo movements several magnitudes greater than the amounts presently observed, if this movement is substantially uniform, without significant structural distress. Future use of the facility should be directed to achieve this consideration.

7. You have requested consideration of a drainage scheme directed to lowering of the groundwater table in the vicinity of the structure. In our opinion a gravity drain will not effectively remove the water (due to a very low permeability in the soil) and, additionally, we do not believe such a water removal will effectively decrease the amount of settlement which the structure will undergo. You may wish to modify the facilities for drainage presently available in the boot pit but we strongly recommend against providing any drainage or other excavations immediately adjacent to the structure mat. Any tendency to lack of confinement or allowance for lateral yield greater than is present with the existing condition could significantly increase settlement obtained with the new silo filling.

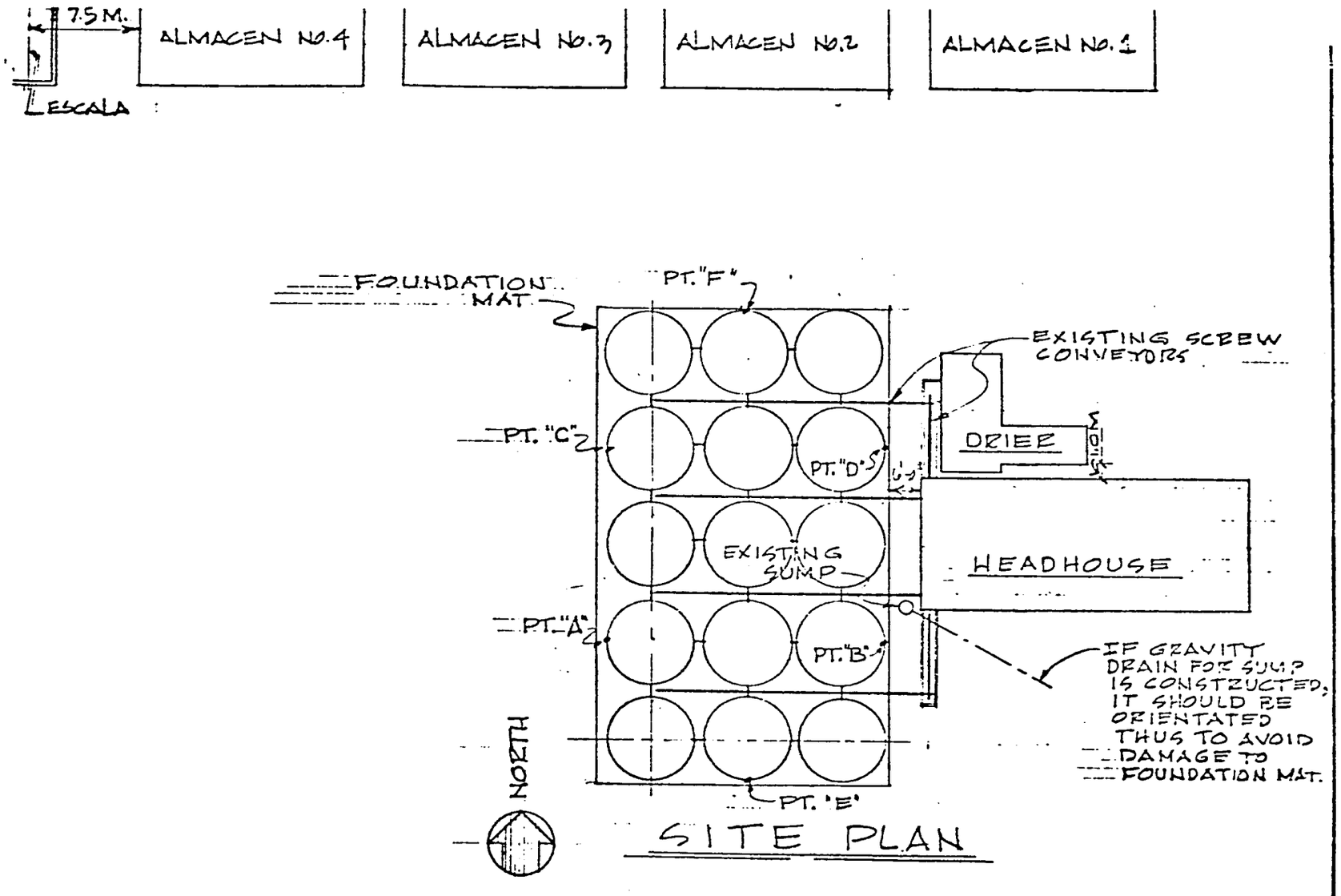
Should these opinions raise questions, or clarification seem desirable, you are welcome to contact this office at your convenience.

Very truly yours,



Donald M. Duncan, P. E.
Vice President

DMD:rg



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