Computer Based Project Analysis and Design

Housing and Urban Development Corporation Limited
New Delhi, India

Technical Assistance Mission Report for Period
October 30 to November 15 and 23, 1981

by

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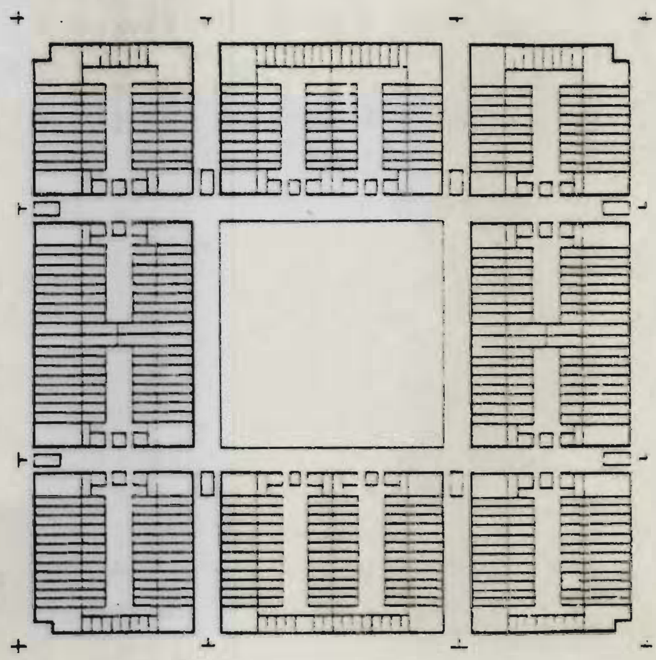
for

National Savings and Loan League
Washington, D.C. 20005

and

Agency for International Development Office of Housing
Washington, D.C. 20523



Laboratory for Computer Graphics and Spatial Analysis
Graduate School of Design, Harvard University
Cambridge, Massachusetts 02138

Report Format

This report is presented in three sections. The first is a single page summary of the accomplishments and future recommendations resulting from the mission. It provides a concise overview of the entire mission and outlines the material presented in greater detail in the second section.

Section two reviews HUDCO's project appraisal needs and proposes research/development, computer equipment acquisition, and follow-up liaison relationships with U.S. counterparts that lead to computer-based project analysis and design aids. This section also describes the substantive work of the mission: definition of optimization models for subdivision design, statistical analysis of residential support land uses, and specification of micro-processor and programmable calculators to support R&D and training programs.

The last section of this report is a set of appendices that contain the following: 1) grant project task list, 2) mission agenda, 3) mission name list, 4) sites-and-service project notes, 5) model for analyzing cluster designs, 6) specifications for HUDCO computer equipment, 7) PADCO/Bertaud model user's guide, 8) example analysis of subdivision layouts, and 9) bibliography of HUDCO technical papers used throughout the mission.

Cover: Diagrammatic representation of cluster block subdivision at 600 Persons/Ha density (from Horacio Caminos 1978).

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Abstract

This mission report summarizes a consultancy from October 30 to November 15, 1981 to the Housing and Urban Development Corporation Limited (HUDCO) in New Delhi, India. The purpose was to advise HUDCO on computer-based methods for project analysis and design and to recommend R&D and equipment procurement that would integrate them into daily operations. HUDCO intends to disseminate the methods to its client agencies through project demonstrations, workshops, and publications.

A number of HUDCO client projects were reviewed and a research agenda analyzing: 1) subdivision layouts with an emphasis on cluster designs, 2) residential support facilities for various densities, and 3) infrastructure costs at increasing project scales was proposed. Example subdivision statistics and a geometric model were written to suggest ways of structuring a post facto analysis of client projects. It was recommended that the research begin by evaluating a set of client projects with the PADCO/Bertaud model. Model documentation, program cards and a calculator were provided.

After reviewing a previous automation study, It was recommended that HUDCO acquire two micro-processor and five calculator systems. Technical specifications and cost data were compiled to initiate import license and tax exemption proceedings.

A tentative schedule for equipment procurement, staff training and mission follow-ups suggests that HUDCO retain a U.S. counterpart. The counterpart would assist in the procurement by demonstrating equipment, pre-testing and shipping it to India. A workshop to introduce HUDCO staff to subdivision analysis and optimization techniques is also proposed. The content and scheduling to be determined by HUDCO.

Project Background [1]

In order to promote and expand the supply of low income shelter in India, the Housing and Urban Development Corporation (HUDCO) of the Ministry of Works and Housing is attempting to improve its project identification, project design and project analysis process. An AID grant will assist HUDCO in this effort by developing a package of micro-computer based models and programs for shelter project identification, design and analysis, costing, cash flow and financial planning. Proposed improvements will permit the comparative analysis of alternative physical design variable and cost of housing projects by utilizing modern computer technology. Development of such systems analysis capability would significantly expand HUDCO's capacity to develop housing projects which meet the physical, social and economic needs of HUDCO's target income groups. Through the medium of training programs including workshops, seminars and field application, HUDCO would transfer the project design and analysis technology to the state and local housing institutions which are its clients and which are the institutions that must in the first instance identify, analyze and design shelter projects which are affordable by the intended target groups and meet the cost and physical design criteria established as part of the government of India's housing policy. Development of this capability will also assist HUDCO in continuously refining and tailoring project design criteria as various cost elements and physical design characteristics change. In this regard, the use of computer technology will permit HUDCO and the state and local housing authorities to analyze the multiple design variables encountered in shelter projects including the alternative site planning, lot sizes, cross subsidies, densities and level and standard of infrastructure vis-a-vis basic affordability criteria for the intended target group.

The project will initially assist HUDCO to design a computer program to permit post facto analysis of approximately 125 existing projects benefiting different income groups for the purpose of development of a reference matrix for project designers which would quantify trade-offs

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[1] Project background is taken from the limited scope grant project agreement between the Agency for International Development (AID) and the President of India. The agreement itself is the most authoritative reference for the overall objectives, terms of technical assistance, grant terms and financial plan. For complete details see: Agency for International Development. "Limited Scope Grant Project Agreement: HUDCO Shelter Design and Analysis (AID Project 912-007)." Washington: Agency for International Development, Office of Housing, June, 1981.

among:

(i) affordability, physical standards, land and related costs;

(ii) cost of infrastructure standards in terms of cost per linear meter of network and the cost per square meter of circulation surfacing;

(iii) the cost of on-site infrastructure per square meter to a given combination of land use and infrastructure standards;

(iv) appropriate superstructure standards-connection costs at each infrastructure adopted;

(v) project viability and composition of projects in terms of different income groups.

The project will also result in the design of micro-computer programs, to permit individual project design and financial analysis utilizing hand calculators. Initial development of this type of computer analysis and the training of planners has previously been carried out with AID support in other countries. Similar systems are proposed to be developed with this grant.

Extension of the micro-computer capability to design financial models and programs including graduated payment mortgage systems, cash flow projections and analysis, cost recovery and subsidy analysis will also be developed as part of the project.

The project will include support to HUDCO's effort to transfer this project design technology to housing agencies throughout India by means of two workshops to be held for senior and mid-level managers in 1981 and 1982.

Earlier this year, AID representatives worked with HUDCO officials to define how computer-based project design and analysis aids could be developed. Appendix 1 lists the tasks suggested at that time. The terms of the mission reported herein approximate tasks 4 to 8 and the initiation of 11.

Models for Project Analysis and Design

HUDCO has given the highest priority to the development of computer based models that optimize land utilization and measure the efficiency of housing subdivision layouts. HUDCO's consultancy group expects to use these models to appraise more than 250 loan applications submitted each year and to disseminate these models to its clients through demonstration projects, consultancy services and training programs.

After considerable discussion with HUDCO division chiefs, it was decided to analyze the following project design components: 1) subdivision layout with an emphasis on cluster designs, 2) residential support facilities for various densities, and 3) infrastructure costs at increasing project scale.

Subdivision Layout

Several empirical studies show that subdivision layout has an enormous effect on initial project costs and longer term public service maintenance costs. [2] Both costs have an obvious relation to the costs that project beneficiaries pay and to the income groups that housing agencies can reach.

A brief review of HUDCO project records showed that many of their clients are unaware of the cost differences or the implementation advantages of various subdivision designs. In view of this, it is recommended that HUDCO undertake a study of the land utilization trade-offs of the various designs. A review of client applications and competition submissions showed that there are two broad subdivision approaches, gridiron and clusters, and that a typology could be created which compares the efficiency of different lot layouts within them.

Appendix 5 reviews some of the differences in the two approaches. An example geometric model was written during the mission to measure the efficiency of one cluster design. Similar analysis should be carried out on a cross section of HUDCO client designs with the objective of identifying common data input requirements, statistical measures of efficiency, cost sensitivity and applicability to various living styles, building traditions, and code restrictions in India.

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[2] See Horacio Caminos. **Urbanization Primer**. Cambridge: MIT Press, 1978 for project assessment, site analysis and design criteria for low-income housing in developing areas.

Appendix 8 • shows one approach to analyzing subdivision layouts. In this study, about 10 variables were considered in 223 housing situations world-wide. Although various housing designs and cultural contexts were included, the study shows that land optimization is a function of block design, density, and the spatial arrangement of support facilites. Summary scattergrams indicate that the relationship between unit circulation length and block-lot area is not lineal but a negatively sloping power function where the least efficient infrastructure results from blocks under .5 hectare. Since infrastructure requirements increase as lot sizes decrease, there is a direct cost incentive in maximizing the amount of residential land (i.e., lot size) where possible.

Residential Support

In addition to investigating optimal subdivision layouts, it is recommended that HUDCO analyze the support land uses associated with increasing densities. As housing projects increase in size, there is a corresponding increase in demand for schools, markets, recreation-open areas, commercial areas and community facilities. These support land uses could be as much as 25% of the total land area of a project.

The basic difference between analyzing alternative block designs and estimating the quantity of residential support areas is that the former is totaly determined by the geometric properties of the design while the latter is largely determined by probabilistic externalities like off-site facilities and local code requirements. The value of analyzing support requirements is to insure that proper land reserves are kept and the capacity of off-site facilities is properly considered when projects are designed.

One possible approach to residential support might be to categorize the major land uses and to list the national and regional code requirements for each. A matrix or table of coeficients for each support category could be developed for the different geographic areas of India. These coeficients could be input to parametric equations that consider the off-site facilities as well. The resulting support requirements can be integrated into the geometric model and the project can be considered as a whole.

Infrastructure Costs

Several HUDCO project chiefs noted that infrastructure costs in client projects are non-lineal. Sewer and water systems, in particular, have discontinuous cost characteristics. A small change in block length, for example, might require a jump to another category of piping or other equipment. Reasonably accurate infrastructure data is available for HUDCO financed projects. It is suggested that the residential support matrix include cost escalation data for basic infrastructure like paving, sewage, storm drainage and water supply. This matrix would be integrated into the model as a set of cost/design constraints on optimization.

PADCO/Bertaud Model

The PADCO/Bertaud model for analyzing alternatives in shelter projects is a significant contribution to HUDCO's goal to develop computer-based project analysis and design aids. Basically, the model is a set of programs for programmable calculators that allow project analyst/designers to compare the trade-off between lot size, density and on-plot construction given the beneficiaries' ability to pay and to cost data for land, site preparation, on/off-site infrastructure, on-plot construction (i.e., core house and/or sanitary unit), and community facilities. Other model programs evaluate projects with different levels of on-plot construction, analyze cash flows based on cross subsidies, and compute the available capital using alternative mortgage schemes like variable payments.

It is recommended that HUDCO initiate its own model research and development by applying the PADCO/Bertaud algorithms and data structure to several of its clients projects. [3] A range of subdivision designs and on-plot housing types should be selected and actual cost data input. It is particularly important to compare projects that use gridiron and cluster subdivision because the latter offers more potential for reducing infrastructure costs and increased residential land utilization.

Output from the model should be compared with actual project histories. It is particularly important to note the model's strengths and weaknesses. For example, how effectively is subdivision layout represented by the various cost parameters that drive the model? Is the model human engineered, does it check for reasonable data and is it adequately documented? The importance of analyzing and applying the PADCO/Bertaud model can not be overstated. The model is a significant contribution to improved shelter projects and subsequent model development can only benefit

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[3] Two sets of manuals and magnetic program cards have been provided. Appendix 7 describes how to use the model on the Hewlett-Packard HP-41CV calculator. PADCO's manuals contain sample work sheets and model equations are listed therein.

from it.

Recommended Computer Systems

In 1976, HUDCO contracted Hindustan Computers Limited (HCL) to review their overall management information needs and to identify critical areas for automation. Three application areas were emphasized in their final report: [4]

1. information storage and retrieval system for all fixed scheme details provided by the borrower with his project report.

2. financial funds flow system including cash flow forecasting, budgeting and control.

3. monitoring of individual project scheme's progress and their evaluation with respect to pre-specified plans.

Micro-processors

After reviewing the HCL analysis of HUDCO's project monitoring and their proposed mini-computer system, it was decided that the development of a project analysis/design system would be more cost-effective if implemented as a separate stand-alone system based on new low-cost micro-processor technology rather than one integrated into a larger and more costly mini-computer system. It is recommended that HUDCO purchase at least two (2) identical micro-processor systems at an approximate cost of $6,000 each rather than invest in a single mini-computer system as HCL suggests. Two systems are needed to provide enough redundancy to insure continuous operation and to facilitate the dual requirements for R&D and staff training.

Several vendors now offer high quality systems under $6,000 that, when properly programmed, can appraise projects, monitor construction advancement and analyze project cash flows. In addition to the cost/performance advantage of micro-processor technology, its high reliability and small-component interchangability make it practical despite the total lack of local vendor support in India.

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[4] Hindustan Computers Limited. "Proposal for Developing and Implementing a Mini-Computer Based Information System for HUDCO." New Delhi: Hindustan Computers Limited, November 1976.

Appendix 6 details three alternative micro-computer systems: Apple's II Plus; IBM's personal computer and Vector Graphic's System 2600. Any one of these systems meet HUDCO's technical requirements. The hardware specifications, required software, technical documentation and cost information are detailed. This data should be used to prepare a general budget and to secure the necessary import licenses.

Unless Indian import proceedings require it, no equipment should be ordered at this time, however. HUDCO representatives should plan to evaluate these systems first hand and, only then, place firm orders. Specific recommendations for equipment procurement, testing and training are made later in this report.

Any of the micro-processors listed in Appendix 6, if properly configured, will provide adequate computation power for project analysis and design. The presence and active use of the system, however, is likely to encourage use in other HUDCO applications like socio-economic survey analysis, loan accounting, overdue monitoring, portfolio management or budget preparation. Apple nd IBM microprocessors can not be sufficiently upgraded to handle the volume of data implied by these other applications. The Vector Graphics, on the other hand, is more expensive than the other two but its Z-80 chip base, S-100 peripheral device interface, and Control Program/Monitor operating system can support many of these other applications. The final choice of micro-processor will depend not only on the R&D proposed here but also on other HUDCO near-term applications.

Micro-Processor Software

Although micro-processor systems are generally delivered with language interpreters, operating system and file handling programs already resident in Read Only Memory (ROM), additional software is required to make them truly operational. HUDCO should budget approximately $2,500 for initial software to be shared between the two systems and another $1,500 for enhancements withing the first year of operation.

The most important software decision will be the choice of operating system. It is recommended that HUDCO adopt the Control Program/Monitor (CP/M) operating system irregardless of which hardware system it acquires. [8] CP/M was originally

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[8] For an introduction to CP/M and operating systems for micro-processors see: Thom Hogan. "CP/M User Guide."

developed for the 8080 and Z-80 family of micro-processors but is has become a quasi-industry standard for software development and is well worth the $300 investment.

In addition to CP/M, it is recommended that HUDCO acquire three high-level language compilers for general programming: BASIC 80, Fortran and Pascal. Their approximate cost is $350 each. Although Fortran has been the traditional language for engineering, statistics and modeling applications on mini- and mainframe computers, BASIC and Pascal are more commonly used with micro-processors. All three languages have National Bureau of Standard definitions, thus programs written for one micro-processor can be run on another vendor's machine. Language standardization should be a systems requirement if HUDCO is to disseminate its programs and procedures to client agencies. Standardized languages facilitate program exchange, insulate the software development group from hardware obselence, and make it possible to use the growing number of program libraries available on the market.

In addition to purchasing standard operating system and language compilers, HUDCO should purchase a general statistical package such as Vector Graphic's STATPAK ($500) and a video-calculator/spread sheet program like Personal Software's "VisiCalc" ($200). These programs will perform the majority of the post facto project analysis. The video-calculator/spread sheet program is particularly useful for project appraisals and comparing the trade-offs of different subdivision designs.

Programmable Calculators

HUDCO fully intends to distribute its computer-based analysis and design techniques to its client agencies. Initial R&D work will be carried out with micro-computers, but the algorithms and procedures will be simplified to operate in field conditions with programmable calculators. Several project planning and management programs have been developed for calculators and their utility is without question.

Appendix 6 lists the specifications for the Hewlett-Packard HP-41CV calculator. This calculator has a large memory capacity, extensive instruction set, and software support for statistical and financial analysis. No alternative is proposed because its cost-performance is superior to other calculators and no other offers the range of peripheral equipment.

Berkeley: OSBORNE/McGraw-Hill, 1981.

It is recommended that HUDCO acquire 4 or 5 complete systems with general statistical and financial analysis programs as soon as possible. They have enough capacity for initial modeling and post facto project analysis. They are also an easy way to learn basic programming and analysis techniques.

Systems cost approximately $900 each and will facilitate an early start on post facto project appraisals and general program development. Larger quantities of the basic system can be acquired as project analysis and design software is developed and HUDCO organizes training courses for its clients. The approximate cost of the basic calculator is $300.

Procurement, Training and Mission Follow-up

HUDCO should apply for the necessary import licenses as soon as possible. The financial viability of the project depends on securing an exemption from import taxes. The equipment specifications in Appendix 6 will provide enough descriptive information to initiate the process.

HUDCO might find it more convenient to retain a U.S. counterpart to assist in equipment procurement, testing, and training. The counterpart can supply technical and cost information for HUDCO's budget preparation and import proceedings. HUDCO should send one or two representatives to the U.S. to examine the proposed micro-processors and to arrange the actual procurement. The counterpart can prepare equipment demonstrations and use this opportunity to review the progress of HUDCO's post facto project analysis and R&D. Demonstrations and reviews ought to be scheduled for late February or early March.

HUDCO should consider equipment procurement a vehicle for introducing staff to computers, statistical analysis, and geometric modeling. The counterpart could design a workshop to introduce HUDCO staff to geometric modeling and computer optimization techniques. HUDCO staff could use the workshop to obtain first-hand experience with programming the equipment and use the workshop to evaluate the progress of their R&D and post facto project analysis. The workshop would also test the completeness of the systems and any shortcommings could be corrected prior to shipping to India. A tentative schedule might be:

HUDCO
Apply for import license and acquire 4 to 5 calculator systems for initial research and application of PADCO/Bertaud model.

Counterpart
Demonstrate micro-processors to one or two HUDCO representative(s), and review the progress of the post facto project analysis and PADCO/Bertaud case studies (February/March).

HUDCO and Counterpart
Counterpart to propose workshop agenda based on HUDCO requirements. Identify HUDCO staff to participate in short-term training in the U.S. The group should be limited to 5 or 6 and include research as well as operations staff who might program and maintain the equipment (April).

Counterpart
Receive and assemble micro-processor systems. Conduct a 2 week workshop in June on computer techniques for project analysis/design using the equipment and software ordered. Evaluate progress of R&D and post facto project analysis. Correct any equipment shortcommings and ship completed systems to India (June).

HUDCO Receive and install equipment (June/July).

General Observations and Comments

Computer usage at HUDCO will increase significantly in the next few years. This consultancy focused on cost-time reduction for appraising and monitoring projects. The issues were largely technical and involved relatively few persons. This entry point was modest and appropriate, but the future demand for computer management aids will be very different. HUDCO managers already feel the pressures of increased project loads, more complex budget preparations, tighter overdue monitoring, agency/client profiles and cost control. Daily operations, such as accounts receivable, project monitoring, profit-loss, loan accounting, socio/economic surveys, and project design optimization are creating their own demands too.

Some of these demands are for improved efficiency, but the challange is to be more effective. Identifying the right management or technical problem to be solved will be more important to HUDCO's success than simply automating the bottlenecks.

The computer entry point -- project appraisal -- is a good one. The goal is simply to improve the quality of design in order to lower the costs of housing. The proposed optimization and geometric modeling are simply techniques that can support the analyst/designer's judgment -- nothing more. This report recommends a modest use of technology, micro-processors and programmable calculators, because they have sufficient power for the task, they are practical for HUDCO and its clients, and they are an affordable way to learn. These recommendations may disappoint advocates for high technology but the basic issue for HUDCO is effective project analysis and design - not computers.

HUDCO has taken a significant step foreward in a process that will greatly improve the quality and quantity of housing to India's economically weaker sector. If they succeed, they will not only fulfill their own mandate for social betterment in India, they will create an example for many others to follow.

APPENDIX 1

Agency for International Development, Office of Housing Limited Scope Grant Project Task List for HUDCO Shelter Design and Analysis (AID Project Number 912-007)

The following list of tasks was developed by HUDCO officials and AID representative Yogesh Chandra to define how computer-based project analysis and design techniques could be developed at HUDCO. The terms of the mission described herein roughly approximate Tasks 4, 5, 6, 7, 8, and initiation of 11. For further grant details, refer to the AID project agreement.[6]

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[6] Agency for International Development. "Limited Scope Grant Project Agreement: HUDCO Shelter Design and Analysis." Washington: Agency for International Development, Office of Housing AID Project Number 912-007, June 1981.

HUDCO-AID Project Shelter Design and Analysis Work Program

Task 1 - HUDCO and USAID

Initial identification of problem and general concept of the methodology to be used to address the problem. Definition of analytical skills required of AID consultant and HUDCO counterparts.

Task 2 - HUDCO

Specification of medium term training required by HUDCO staff. Current level of expertise of HUDCO staff proposed for such training in the U.S.A. and expected outputs/results of such training.

Task 3 - AID

Initial identification of sources of such training in the U.S. and proposed duration of such training.

Task 4 - HUDCO

Identification of the contours of requirement for development of model based shelter design and analysis. Definition of expectations of the model and expected outputs and submission to the AID Office of Housing.

Task 5 - HUDCO

Identification of type of information available from 125 already sanctioned projects which will be used as a basis for preparing the model and submission of the information to AID Office of Housing.

Task 6 - HUDCO

Compilation of information from a sample of projects, which will be used for the model.

Task 7 - AID

Identification of U.S. counterparts to work with HUDCO counterparts on model building and inform HUDCO of counterparts background and availability.

Task 8 - HUDCO

Identification of HUDCO counterpart staff to work with U.S. counterpart.

Task 9 - HUDCO

Identification of HUDCO staff to participate in short term training in the U.S. (Office of Housing Shelter Workshop in October-November 81).

Task 10 - AID

Provide short term training to HUDCO staff in the

U.S. (Office of Housing Shelter Workshop in October-November 81)

Task 11 - HUDCO and AID

U.S. counterpart to work on model building for shelter design projects in Delhi with HUDCO staff at a mutually agreed time. Length of visit to be approximately 4-5 weeks. Specifics to be determined upon completion of tasks 4 and 5. This may entail collection of additional information. Expected output would be complete definition of model, based on HUDCO's requirements.

Task 12 - HUDCO

Further collection of information and work on model based upon the results of Task 11.

Task 13 - HUDCO and AID

HUDCO counterparts to visit U.S. to follow up and complete work on the model, working with U.S. counterpart in model building. Work with AID Data Management Expert to determine the type of micro-computer and hand calculators best suited for HUDCO's requirements. Also as per Task 13, finalize arrangements for medium term training of HUDCO staff in the U.S.

Task 14 - HUDCO and AID

HUDCO staff visits U.S. for medium term training, based on results of Task 13. This training to be funded from second year grant funding.

Task 15 - AID

Purchase the equipment and send it to HUDCO.

Task 16 - AID

Field test the model in India.

Task 17 - HUDCO

Complete documentation of the model and training guidelines.

Task 18 - HUDCO and AID

First HUDCO workshop for technology transfer in India. U.S. counterpart along with HUDCO staff in this training program.

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APPENDIX 2

Technical Assistance Mission Agenda
October 31 to November 15 and 23, 1981

National Savings and Loan League - NSLL

Agency for International Development - AID

Housing and Urban Development Corporation - HUDCO

Uttar Pradesh Housing and Development Board - UP HUDB

Harvard Laboratory for Computer Graphics - LCGSA

Massachusetts Institute of Technology - MIT

Date	Location	Time	Schedule
SEPTEMBER			
30	Boston	9:00 - 11:00	Travel Boston to Washington Eastern flight 375
	Washington	12:00 - 14:00	Mission review Mr. Robbins (NSLL) Ms. Ramos (NSLL)
		14:00 - 17:30	AID/HUDCO grant review at AID Shelter Institute Mr. Kumar (HUDCO) Mr. Mann (AID)
		19:30	Depart Dulles for London Pan Am flight 106
31	London	5:45	Arrive London
NOVEMBER			
1	London	8:55	Depart London for New Delhi British Airways flight 147
2	New Delhi	3:40	Arrive New Delhi
		13:00 - 15:00	Mission review at AID Mr. G.P. Varshneya (AID)
		15:00 - 17:30	Overview of HUDCO's project appraisal Mr. Chakraborty (HUDCO) Mr. Mulka Raj (HUDCO)
3	New Delhi	10:00 - 12:00	Review of construction shared-wall optimization studies at HUDCO. Mr. Chakraborty (HUDCO)
		12:00 - 15:00	Review of project monitoring and finance at HUDCO. Mr. Ahuja (HUDCO) Mr. Mulka Raj (HUDCO)
		15:00 - 17:30	Review of PADCO/Bertaud project appraisal model Mr. Mulka Raj (HUDCO)
4	New Delhi	10:00 - 13:00	HUDCO Consultancy review. Mr. M.N. Joglekar (HUDCO)
		13:00 - 17:00	Presentation of computer equipment alternatives for HUDCO R&D and training

			workshops. Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
5	New Delhi	10:00 - 12:00	PADCO/Bertaud model review Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
		12:00 - 17:00	Cluster model proposal Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
6	New Delhi	10:00 - 13:00	Field trip to HUDCO demonstration project Bodella Vikaspuri, New Delhi Mr. Ahuja (HUDCO) Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
		14:00 - 16:30	Reception with HUDCO Staff Mr. H.U. Bijlani (HUDCO) Mr. Ahuja (HUDCO) Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
9	New Delhi	9:00 - 12:45	Preparation of computer hardware specifications, outline required mission report and plan field trip. Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
		13:00 - 14:00	Luncheon reception AID/HUDCO Mr. H.U. Bijlani (HUDCO) Mr. Ahuja (HUDCO) Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO) Mr. H.K. Yadav (HUDCO)
		14:00 - 17:00	Programming cluster model example for pocket calculator Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
10	New Delhi	10:00 - 14:00	Prepare specifications for importation tax exemption of micro-processor computers and hand-held calculators. Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
		14:00 - 17:50	Lecture/discussion of computer aided subdivision design Lecture attended by all HUDCO technical and administrative staff
11	Lucknow	5:30 - 10:30	Travel to Lucknow Air India flight 409

		10:30 - 17:30	Uttar Pradesh Housing and Development Board Projects Ram Sagar Misra Magar and Raja-Ji-Puram Yojna. Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO) Mr. Bensol (UP HUDB) Mr. Natutiyal (UP HUDB) Mr. Verma (UP HUDB)
12	Lucknow	9:00 - 12:30	Travel to New Delhi Air India flight 410
		12:30 - 17:00	Review of R&D schedule and future technical assistance Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
13	New Delhi	8:30 - 10:00	Review of mission at AID Mr. Malick (AID) Mr. Varshneya (AID)
		10:00 - 13:00	Prepare draft report Mr. Chakraborthy (HUDCO) Mr. Mulka Raj (HUDCO)
14	New Delhi	2:30 - 11:00	Travel from New Delhi to London Pan Am flight 001
15	London	10:30 - 15:50	Travel London to Boston TWA flight 753
23	Boston	9:00 - 12:00	Presentation of Manila Tondo sites-and-servies project, Manila. Urban Dwellings Design Group, MIT. Dean John De Monchaux (MIT) Prof. Horacio Caminos (MIT) Prof. Reinhard Goethert (MIT) Mr. Vije Kumar (HUDCO)
		12:00 - 14:00	Demonstration of IBM personal computer at IBM Customer Service Center, Boston Mr. Vije Kumar (HUDCO)
		14:00 - 17:00	Tour of Harvard Laboratory for Computer Graphics and Spatial Analysis. Demonstration of computer aided design, geometric modeling and mapping software. Mr. Vije Kumar (HUDCO) Mr. Bruce Donald (LCGSA)

APPENDIX 3

Mission Name List

The following list of persons were interviewed during the mission.

United States Agency for International Development
U.S. Embassy, New Delhi

Mr. Jeffery Malick - Project Development Officer

Mr. G.P. Varshneya - Assistant to Project Development Office

Housing and Urban Development Corporation Limited
New Delhi, India

Mr. H.U. Bijlani - Chairman and Managing Director

Mr. G.S. Ahuja - Chief of Finance

Mr. B.K. Chakraborty - Chief of Projects I

Mr. H.K. Yadav - Chief of Projects II

Mr. Mulkh Raj - Manager Economic Evaluation

Mr. G.R. Viswanathan - Manager Project Construction

Mr. M.N. Joglekar - Manager Project Consultancy

Mr. ViJy Kumar - Manager Statistical Evaluation

Mr. Anoop Agarwal - Manager Law

Calcutta Metropolitan Development Authority

Mr. P.K. Dutta - Acting Director

Uttar Pradesh Housing and Development Board
Lucknow, India

Mr. S. Bansol - Superintending Engineer

Mr. D.C. Natutiyal - Project Coordinator

Mr. Monoharlal Verma - Assistant Engineer

APPENDIX 4

Sites-and-Services Project Notes

Paja-Ji-Puram Yojna
Lucknow, India

Raja-Ji-Puram Yojna
Sites-and-Serivices Project
Uttar Pradesh Housing Development Board
Lucknow, India

The Raja-Ji-Puram Yojna sites-and-services project is a HUDCO financed project for the economically weaker sector and low-income groups (EWS and LIG) of Lucknow. The 740 acre site is located 4 km from Charbagh Rail Road Station next to Aish Bagh industrial park. Approximately 40 hectars have already been developed: 56% residential, .5% shopping/commercial, 2% community buildings, 12% parks and open space and 28% circulation.

10,370 units have been sanctioned and 9,150 have been built. 1,006 sites are 32 square meter lots with 10.8 square meter room and water closet.

Constructed Plinth Area	15.6 square meters
Service Core	1.20 X .90 meter water closet
Single Room	2.4 X 4.5 meters
Water	PVC stand pipes @ 10 to 15 houses
Sewerage	Main lines laid. Individual connections made by allottee
Electrification	Connection made by allottee
Roads	12 and 9 meter width main roads with metalled surface. 6 and 3 meter wide brick on edge paving. Storm drains on all roads of 6 meter and above.
Cost of Land Development	R53/square meter
Cost of Construction	R2,628 per unit actual R2,680 per unit sanctioned $R1,300 additional for W.C.

Typical Dwelling Unit Construction

Figures 4.1 through 4.5 illustrate the basic growth stages of a typical sites-and-services unit using pucca construction Figure 4.1 shows Stage 1, the basic plinth area and a complete water closet costing R3,928. Stage 2, Figure 4.2, expands to include construction of a pucca room over the previously built plinth with bamboo walls in 1:3 lime morter and reinforced brick roof. This stage costs R9,412. Stage 3 extends two more rooms at a cost of R14,900. See

Figure 4.3. Total cost of the house with staircase and one room and water closet unit constructed on the first floor (foreground unit in Figure 4.5) is R22,000. The total cost of stage 5 with all four rooms constructed is $R25,550.

Meter Plinth Area on 32 Square Meter Lot (R2,020)

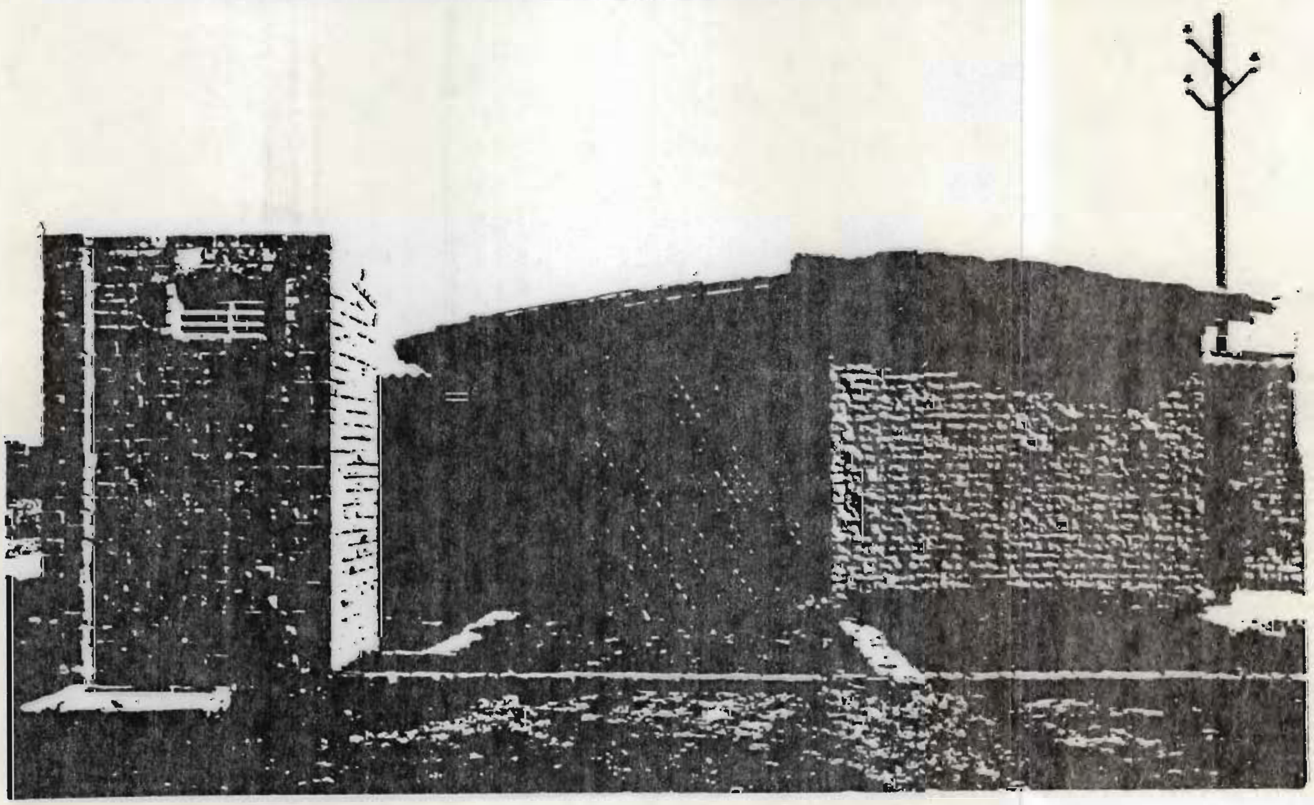

Figure 4.2 - Basic Service Core Unit with Bamboo
Jafri Walls and Thatched Roof (R4,757)

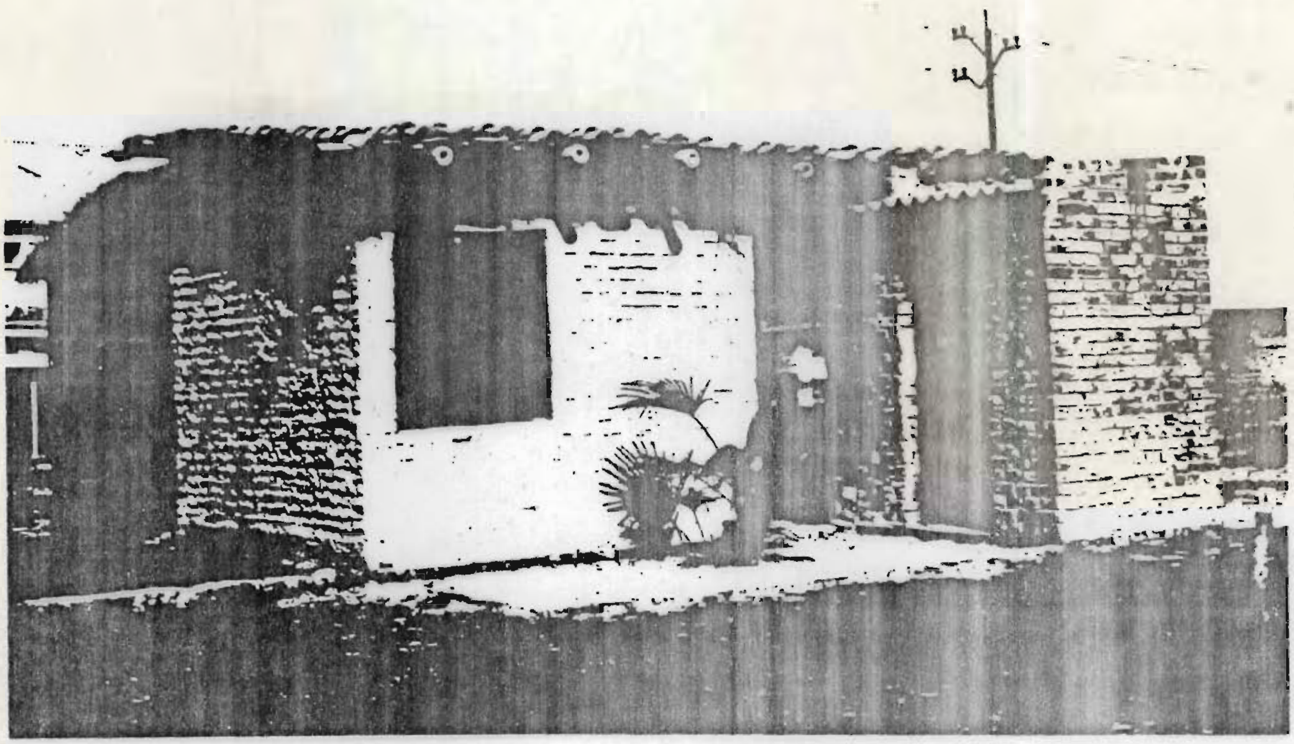

Figure 4.3 - Basic Service Core Unit with Sundried Brick Walls and Tile Roof (R5,370)

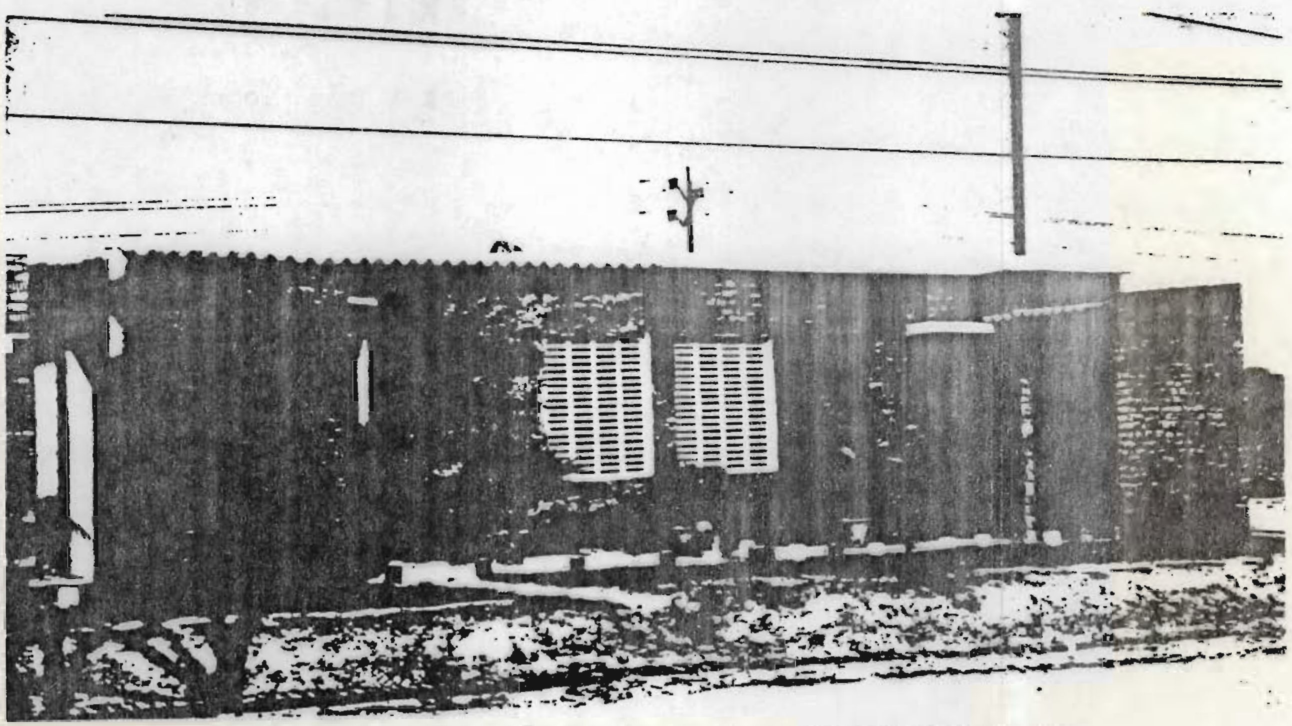

Figure 4.4 - Left Unit: Basic Service Core Unit with Sundried Brick Walls and Asbestos Cement Roofing (R5,753). Right Unit: Pucca Brick Wall in Mud Morter with Reinforced Brick Roof (R7,000).

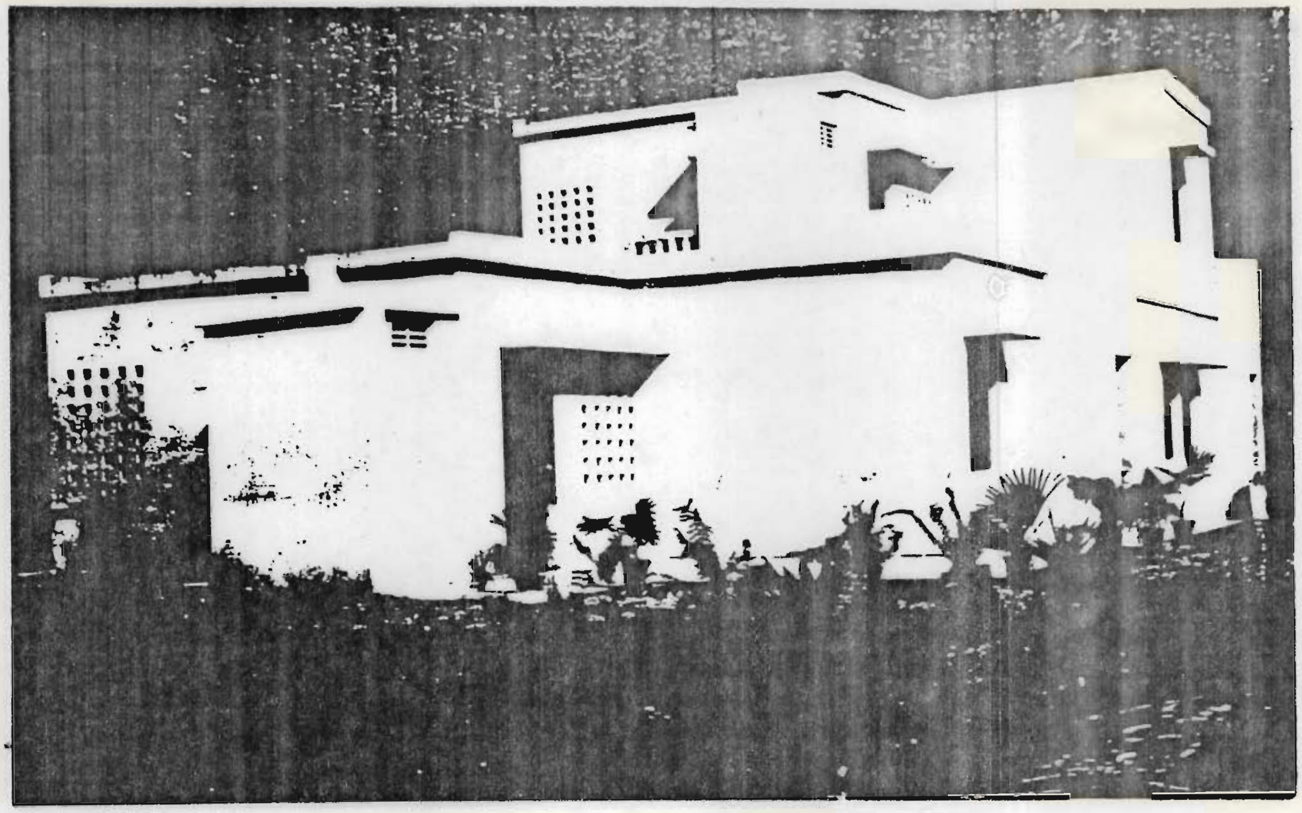

Figure 4.5 - Demonstration Units Showing Single Floor
and Multi-Floor Expansion Possibilities.

APPENDIX 5

Example Model for Analyzing Cluster Designs

The following geometric model was developed to evaluate the possible trade-offs between gridiron and cluster block designs. It was written to demonstrate how to analyze subdivision designs, to see how much data would be required to make meaningful comparisons, and to test to what extent HUDCO could use such models to evaluate the efficiency of subdivisions that were proposed by clients for funding.

The model and accompaning Hewlett Packard HP-41CV program showed that a significant amount of the initial model work could be done with this class of programmable calculator. Preliminary analysis with the calculator showed that cluster block designs are significantly more efficient and diverse in design form than their gridiron counterparts.

The following describes how a typical block design was programmed and how the output was analyzed. Although the programming and analysis were completed in less than two days, the results showed that geometric modeling can lead to significant improvement in land utilization and that further analysis of HUDCO projects should be undertaken to create a comparative base.

Background

The block is the basic unit or residential subdivision. The choice of what design to use profoundly affects initial and longer-term operating costs. Inappropriate designs waste land, reduce taxable property, and lead to higher service charges for utilities.

Theoretically, a block could consist of as few as four lots grouped around some common point such as a well or sanitary unit. More typical, however, a block is a double row of lots back-to-back. Figure 5.1 shows several common gridiron designs. The overall length and width of a gridiron block is a function of the area, proportions, and the number of lots it contains. Blocks of this kind are usually bounded on all four sides by public circulation. The distances between streets in either direction is called the circulation interval. [7]

The interval or spacing between lines of circulation is a compromise between small intervals that maximize pedestrian accessibility to various points on- and off-site, and large intervals that reduce the total number of streets and thus the overall proportion of the project area used for circulation. Accessibility and circulation intervals are inversely related; accessibility rises when intervals are small and there are more streets, but so do costs and the proportion of land not available for home construction. In most countries, municipal ordinances regulate the maximum distance that fire equipment can pump water. This is approximately 100 meters, which means the maximum block length is about 150 to 300 meters (water could be pumped 100 meters from either end of the block and still reach all points.

For simple gridiron designs with back-to-back lots, circulation intervals are very sensitive to changes in lot proportions. For example, consider the differences between two block designs in which the only change is the proportion of the lot. The first contains 22 square lots each 100 meters square. The second design contains lots of 100 square meters but the proportions have been changed from 1:1 to to 1:2.7. By changing just the lot proportions while holding the lot area and block length constant, the second design yields 36 lots while the first only yields 22. The interval spacing of the circulation parallel to the short side of the block has increased with the deeper lots. The block width has increased from 20 to 33.32 meters, while

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[7] For a complete analysis of circulation types, see Horacio Caminos and Reinhard Goethert. Urbanization Primer. Cambridge: MIT Press, 1979.

block length and street width were held constant in order to compare the results. This means the second design has 30% fewer streets parallel to the long axis of the block than the first design; a significant cost reduction right away. Figure 5.1 shows the two block design side by side. An index of efficiency of lineal utilities (i.e., streets, water and sewer lines, or electrical networks) results when the ratio of the block circulation length is compared to the block area. * This index, called the R factor, or unit circulation length (UCL), is computed by dividing the total circulation length by the block area, Block length for the first case is 220 meters (half the perimeter of the block, the other half belongs to the adjacent blocks), and 140 meters for the second. Block areas are 4,000 and 8,000 square meters respectively. This results in UCLs of .06 meters of utilities per hectare for the first design and .03 for the second. The second is therefore twice as efficient as the first because only half the amount of lineal utilities is needed to service the same area.

Figure 5.2 shows an alternative block design called the cluster. Unlike gridiron blocks where the circulation interval is a function of the lots, cluster design are independent. Cluster designs devide circulation into two classes instead of just one: 1) circulation through the site and 2) access to individual lots. With this distinction, a constant but considerably improved index for unit circulation length, and percentage of private and semi-private land utilization results. Statistical analysis shows that all cluster designs for a constant density of 600 persons per hectare result from varying lot proportions from 1:1 to 1:4 and areas from 20 to 400 square meters result in UCLs of 150 meters per hectare (M/ha) and percent of land for residential use (%Res) or 62.5% respectively. This is a considerable improvement over the 232 M/ha and 55% values for the mean 160 square meter lots in gridiron designs.

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* Horacio Caminos. "A Method for the Evaluation of Urban Layouts." **Industrialization Forum**, 3 (December, 1971).

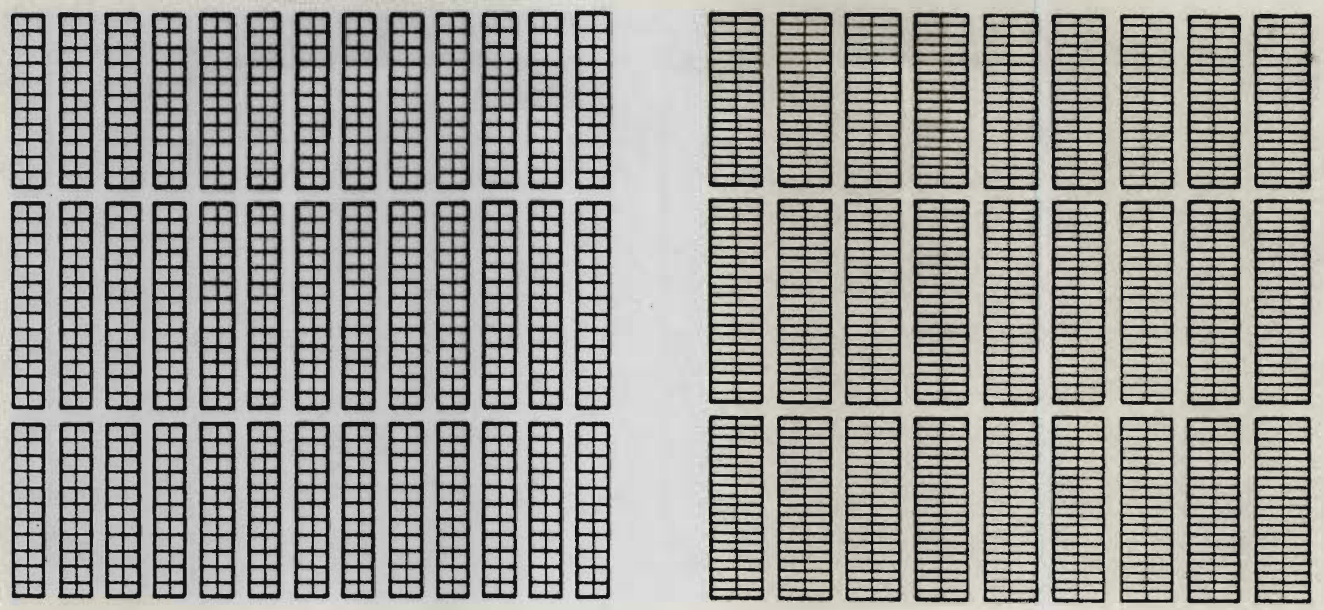

Figure 5.1 - Comparative Gridiron Block Designs

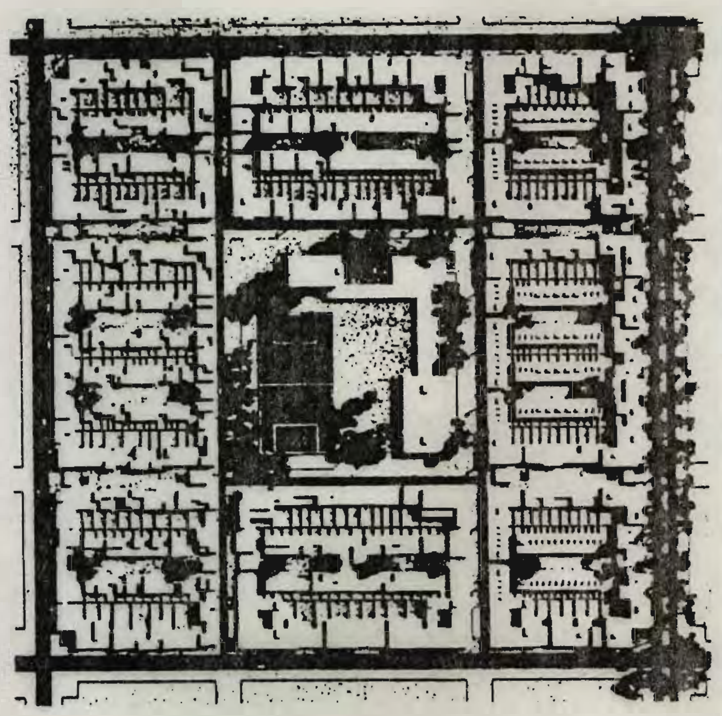

Figure 5.2 - Typical Cluster Blocks

A Geometric Model for Cluster Blocks

To optimize subdivision layouts, some accounting mechanism must be created to measure the trade-off effects of changing physical design parameters such as block length, lot area, lot proportions, and circulation/access widths. The interrelationships of these variables are totally determined by the geometry of the design; thus, it is possible to write a simple geometric model to measure them. Figure 5.3 shows a simple cluster block whose module can be increased by one or more bays. Geometric dimensions have been assigned a variable name. For a given cluster block, the maximum block length, lot area, minimum lot width, primary and secondary street widths, and numbers of persons per family can be stated. These input parameters then determine the block width, the total number of lots, the amounts of residential-circulation space and the total density possible.

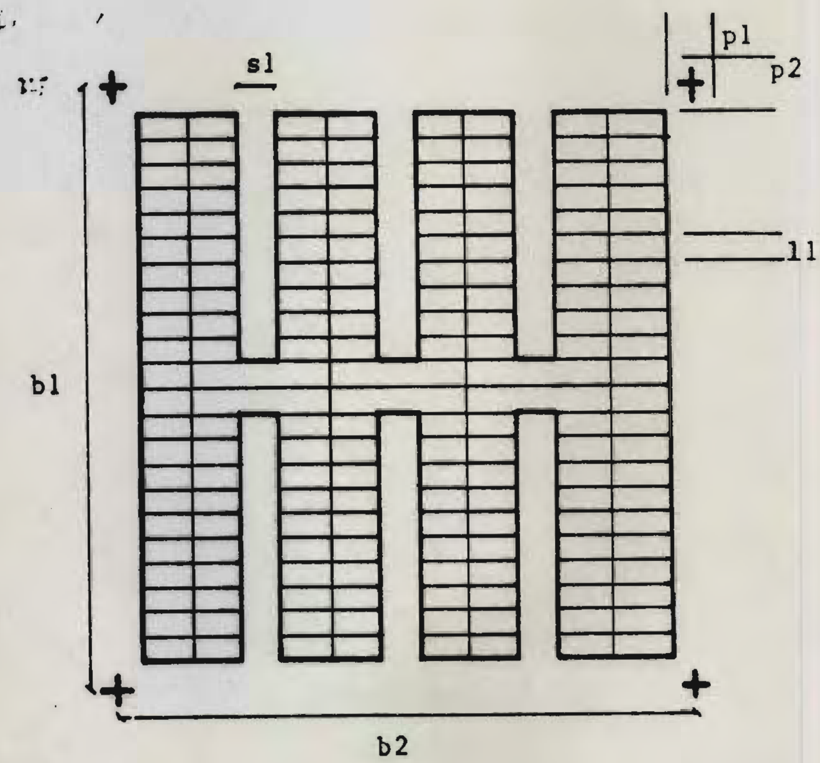

Figure 5.3 - Parameters for ~~Three~~ FOUR Bay Cluster Block

To facilitate the calculations, a simple programmable calculator program was written (see Figures 5.12 and 5.13 for program listing and magnetic card copy). Figure 5.4 shows what data is required; most of the variables are computed by the model but some must be supplied before the program can be used. Figure 5.5 shows the input data used to analyze a 3 bay cluster like Figure 5.3. Figure 5.6 shows the results.

DATA REGISTER	MODEL PARAMETER	TYPICAL VALUE	MODEL USAGE
R00 *	b1	100 meters	Block width (y axis)
R01	b2	computed	Block length (x axis)
R02 *	p1	6 meters	Primary street (y axis) width
R03 *	p2	6 meters	Primary street (x axis) width
R04 *	s1	4 meters	Secondary access way width
R05 *	l1	6 meters	Lot width
R06	l2	computed	Lot depth
R07	l	computed	Number of lots per block face
R08 *	A	50 sq mts	Area of lot
R09 *	B	2 to 6	Number of repeated bays
R10	b3	computed	Total block area (to center line of petimeter streets)
R11	L	computed	Total lots per block
R12	R	computed	Total residential area
R13	%R	computed	% residential
R14	P	computed	Total primary street area
R15	%P	computed	% primary streets
R16	S	computed	Total secondary access area
R17	%S	computed	% secondary access might be considered open space or building setback under some design situations.
R18 *	N	5 to 7	Number of persons per family
R19	D	computed	Density (persons per hectare)

* Register locations 00, 02, 03, 04, 05, 08, 09, and 18 must be given appropriate data values before the CLUSTER program is executed. All other model values are computed, stored in the indicated register and then displayed one at a time. All model variables (parameters as well as computed values) can be saved on a magnetic card for future use. Simply attach the HP-41CV card reader, key 0.019 into the X register, execute the "WDTAX" write-data-x function, and supply a blank card to the reader on when it requests it. Be sure to label the card accordingly.

Figure 5.4 - CLUSTER Program Data Requirements and Usage

CLUSTER PARAMETER	COMMENTS
100.000 STO 00	Set block width (y axis)
6.000 STO 02	Primary street width (y axis)
6.000 STO 03	Primary street width (x axis)
4.000 STO 04	Secondary access width
6.000 STO 05	Lot width
50.000 STO 08	Lot area
3.000 STO 09	Number of cluster bays
5.000 STO 18	Family size

Figure 5.5 - CLUSTER Input Parameter Example

```
XEQ "CLUSTER"

*CLUSTER*

BLK WD=100.
BLK LEN=64.
LOT AREA=50.
LOTS=84.
RES=4,392.
%RES=0.69
STREETS=948.
%STREETS=0.15
ACCESS=576.
%ACCESS=0.09
FAMILY=5
DENSITY=656.
COPY DATA?
 N

END
```

Figure 5.6 - CLUSTER Program Output for Above Parameters

Analyzing the Output

The value of geometric modeling comes from measuring the effect of one variable on a whole system. Writing models and analyzing their output leads to improved design judgement because one can creatively manipulate lot areas, street widths, etc. to achieve some desireable objective function like maximizing residential land or minimizing the infrastructure requirements. The model itself is simply an accounting mechanisms for maintaing consistent relationships between the different physical design parameters.

Figures 5.7 through 5.10 compare clusters of 2 to 5 bays for 50 and 100 square meter lots with 3.6 and 6 meter lot widths. The comparison shows how sensative the available residential land is to changes in these variables. To make design comparisons possible, one block dimension, circulation widths, and persons per family were held constant.

Preliminary output shows that this particular type of cluster design has the following design properties:

1) Increases in the number of bays:

   a) has only marginal effect on density
   b) significantly decreases primary streets
   c) increases the amount of access ways (access areas, if properly dimensioned, could be considered open space)
   d) has slightly positive effect of amount of land available for residential construction

2) Increasing the area of the lot:

   a) lowers density
   b) significantly reduces infrastructure

It is important to note that all cluster designs achieved above 65% residential land utilazion and that the percentage of land used for primary streets averaged 13%; both statistics are a considerable improvement over gridiron block designs.

CLUSTER PARAMETER	NUMBER OF CLUSTER BAYS 2	3	4	5
Block Width	100	100	100	100
Block Length	66	97	129	161
Lot Width	3.6	3.6	3.60	3.60
Lot Area	50	50	50	50
Lots	104	156	208	260
Residential	5,258	7,915	10,573	13,230
%Residential	80%	81%	82%	82%
Prim. Streets	957	1,148	1,339	1,529
%Prim. Streets	15%	12%	10%	10%
Access	346	691	1,037	1,382
%Access	5%	7%	8%	9%
Family Size	5	5	5	5
Density	793	801	806	808

Figure 5.7 - Clusters with 2 to 5 Bays, 50 Square Meter Lots with 3.6 Meter Width.

CLUSTER PARAMETER	NUMBER OF CLUSTER BAYS 2	3	4	5
Block Width	100	100	100	100
Block Length	121	181	240	300
Lot Width	3.6	3.6	3.6	3.6
Lot Area	100	100	100	100
Lots	104	156	208	260
Residential	10,458	15,715	20,973	26,230
%Residential	86%	87%	87%	87%
Prim. Streets	1,291	1,648	2,005	2,363
%Prim. Streets	11%	9%	8%	8%
Access	346	691	1,037	1,382
%Access	3%	4%	4%	[illegible]%
Family Size	5	5	5	5
Density	429	432	433	434

Figure 5.8 - Clusters with 2 to 5 Bays, 100 Square Meter Lots with 3.6 Meter Width.

CLUSTER PARAMETER	NUMBER OF CLUSTER BAYS 2	3	4	5
Block Width	100	100	100	100
Block Length	43	64	85	105
Lot Width	6	6	6	6
Lot Area	50	50	50	50
Lots	56	84	112	140
Residential	2,896	4,392	5,888	7,384
%Residential	67%	69%	70%	70%
Prim. Streets	824	948	1,072	1,196
%Prim. Streets	19%	15%	13%	11%
Access	288	576	864	1,152
%Access	7%	9%	10%	11%
Family Size	5	5	5	5
Density	646	656	661	665

Figure 5.9 - Clusters with 2 to 5 Bays, 50 Square Meter Lots with 6 Meter Width.

CLUSTER PARAMETER	NUMBER OF CLUSTER BAYS 2	3	4	5
Block Width	100	100	100	100
Block Length	77	114	151	189
Lot Width	6	6	6	6
Lot Area	100	100	100	100
Lots	56	84	112	140
Residential	5,696	8,592	11,488	14,384
%Residential	74%	75%	76%	76%
Prim. Streets	1,024	1,248	1,472	1,696
%Prim. Streets	13%	11%	10%	9%
Access	288	576	864	1,152
%Access	4%	5%	6%	6%
Family Size	5	5	5	5
Density	365	368	370	371

Figure 5.10 - Clusters with 2 to 5 Bays, 100 Square Meter Lots with 6 Meter Width.

PARAMETER	ALGEBRAIC EXPRESSION
Block Width	b1 = input parameter
Block Length	b2 = ((B * 2) * 12) + ((B - 1) * s1)
Block Area	b3 = b1 * b2
Number of Bays	B = input parameter
Primary Street Width (y axis)	p1 = input parameter
Primary Street Width (x axis)	p2 = input parameter
Access width	s1 = input parameter
Lot Area	A = input parameter
Lot Width	l1 = input parameter
Lot Depth	l2 = A / l1
Lots/Block Face	l = (Integer(Absolute(b1 / l1))/ 2) * 2
Total Lots	L = (B * 2) * l
Residential Area	R = L * A
%Residential	%R = R / b3
Primary Streets	P = (b1 * p1) + (b2 * p2) - (p1 * p2)
%Primary Streets	%P = P / b3
Access	S = (((((L / 2) - 1)* l1)* s1)* 2)* (B - 1))
%Access	%S = S / b3
Family Size	N = input parameter
Density	D = ((N * 10,000) * L) / b3

Figure 5.11 - Equations used in CLUSTER Program

```
01•LBL "CLUSTER"
02 "  *CLUSTER*"
03 AVIEW
04 PSE
05•LBL 01
06 RCL 00
07 RCL 03
08 -
09 RCL 05
10 /
11 2
12•LBL 02
13 /
14 INT
15 2
16 *
17 STO 07
18•LBL 04
19 RCL 08
20 RCL 05
21 /
22 STO 06
23•LBL 05
24 RCL 09
25 2
26 *
27 RCL 05
28 *
29 RCL 04
30 RCL 09
31 1
32 -
33 *
34 +
35 RCL 03
36 +
37 STO 01
38•LBL 06
39 RCL 00
40 *
41 STO 10
42•LBL 07
43 RCL 07
44 2
45 *
46 RCL 09
47 *
48 STO 11
49 RCL 08
50 *
51 STO 12
52 RCL 09
53 1
54 -
55 4
56 *
57 RCL 05
58 *
59 RCL 04
60 *
61 ST+ 12
62 RCL 12
63 RCL 10
64 /
65 STO 13
66•LBL 08
67 RCL 00
68 RCL 02
69 *
70 RCL 01
71 RCL 03
72 *
73 +
74 RCL 02
75 RCL 03
76 *
77 -
78 STO 14
79 RCL 10
80 /
81 STO 15
82•LBL 09
83 RCL 07
84 2
85 /
86 1
87 -
88 RCL 05
89 *
90 RCL 04
91 *
92 RCL 09
93 1
94 -
95 2
96 *
97 *
98 STO 16
99 RCL 10
100 /
101 STO 17
102•LBL 10
103 RCL 18
104 10000
105 *
106 RCL 11
107 *
108 RCL 10
109 /
110 STO 19
111 TONE 9
112 "*RESULTS"
113 FIX 0
114 RCL 00
115 "BLK WD"
116 XEQ 88
117 RCL 01
118 "BLK LEN"
119 XEQ 88
120 RCL 08
121 "LOT AREA"
122 XEQ 88
123 RCL 11
124 "LOTS"
125 XEQ 88
126 RCL 12
127 "RES"
128 XEQ 88
129 FIX 2
130 RCL 13
131 "%RES"
132 XEQ 88
133 FIX 0
134 RCL 14
135 "STREETS"
136 XEQ 88
137 FIX 2
138 RCL 15
139 "%STREETS"
140 XEQ 88
141 FIX 0
142 RCL 16
143 "ACCESS"
144 XEQ 88
145 FIX 2
146 RCL 17
147 "%ACCES"
148 XEQ 88
149 FIX 0
150 RCL 18
151 "FAMILY"
152 XEQ 88
153 RCL 19
154 "DENSITY"
155 XEQ 88
156 CLA
157 "COPY DATA?"
158 AON
159 PROMPT
160 AOFF
161 ASTO Y
162 "N"
163 ASTO X
164 X=Y?
165 GTO 99
166 0.029
167 WDTAX
168 GTO 99
169•LBL 88
170 "⊢="
171 ARCL X
172 AVIEW
173 STOP
174 RTN
175•LBL 99
176 "  END"
177 AVIEW
178 TONE 9
179 .END.
```

Figure 5.12 - CLUSTER Program for Hewlett Packard HP-41CV Programmable Calculator

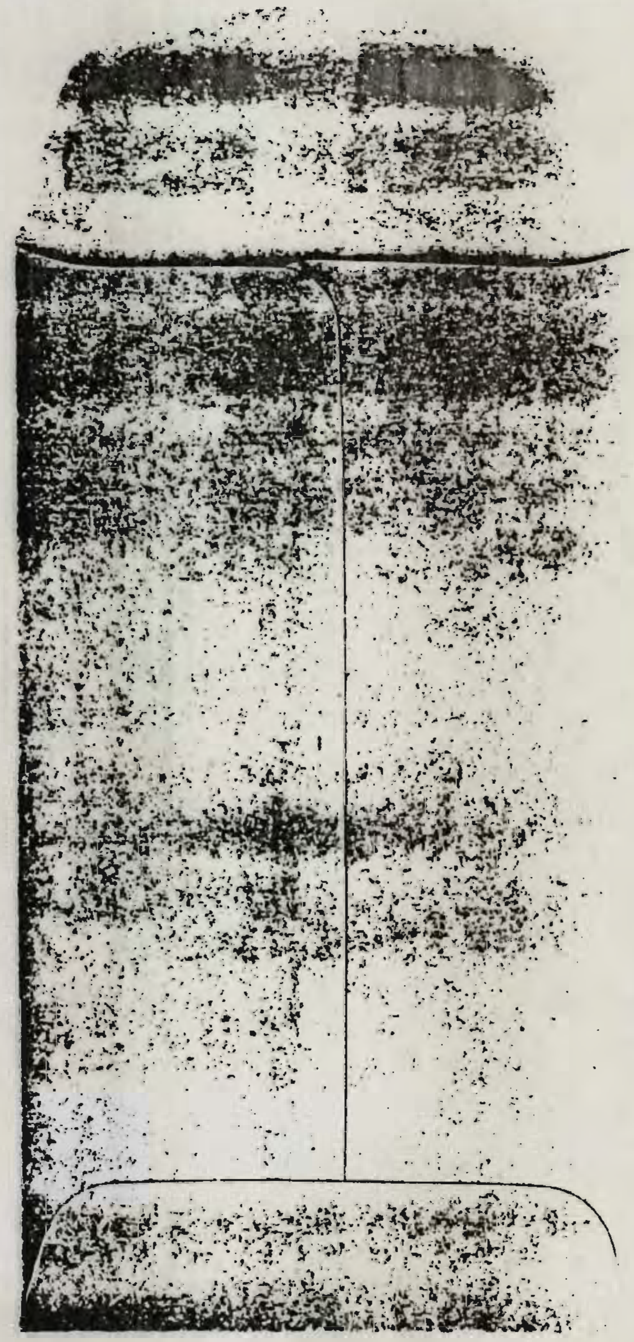

Figure 5.13 - CLUSTER Program Cards for Hewlett Packard HP-41CV Programmable Calculator

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NO. 42

APPENDIX 6

Computer Equipment Specifications for HUDCO Research/Development and Training Facility

The following specifications describe two alternative micro-processor computers and one hand-held programmable calculator. This equipment meets the technical requirements of HUDCO for the research and development of project appraisal techniques and the dissemination of such techniques to client agencies. Micro-processor alternative I is the APPLE II Plus personal computer produced by Apple Inc.. Alternatives II and III describe IBM's personal computer and the System 2600 by Vector Graphic Inc. Although the APPLE II Plus has some marginal software advantages over the other two (Apple Inc. has a 5 year lead) all systems will perform satisfactorly and be comparable within 10% cost. Final selection of equipment should be based on the ability to interface peripherals from Other Equipment Manufacturers (OEMs), use standard software based on the architecture's chip, system documentation, and maintenance support.

No alternative has been proposed for the Hewlett-Packard hand-held programmable calculator. Its cost-performance is superior to other manufacturers equipment and none other offers the range of peripheral equipment.

Manufacturers reserve the right to change their technical specifications, software licensing terms, and equipment costs. The prices noted here are for estimation purposes only and were suggested retail prices as of November 1981. In general, prices for hardware and software are declining, thus the quotations listed here will tend to be higher than actual procurement costs.

Alternative I
Apple II PLus Personal Computer
Apple Computer Inc.
Cupertino, California

General Systems Hardware

High-performance micro-processor employing 6502 chip architecture with 48K bytes of Random Access Memory (RAM), cassette interface, and I/O port connections to include:

- ASCII typewriter-style keyboard 83-key keyboard with upper case alphabet and enhancements for lower case.
- Operating power 220/240v, 50/60 Hz.
- Read Only Memory (ROM) board micro-programs to include: *
    - Disassembler
    - Automatic input/output device assignment
    - Keyboard and screen editor
    - Register examine/modify and read/write cassette routines
- Floppy disk subsystem:
    - Random/sequential access method disk with arbitrary record lengths
    - 116K byte disk capacity (formatted) or soft-sectored (143K bytes with Pascal)
    - Controler unit interface card
    - Floppy disk interface card
    - Bootstrap program in ROM for loading disks
    - Connecting cables
- Medium speed inpact printer 80 X 132 dot matrix chatacters (5 X 7) per line at 60 characters per second speed, full ASCII 64 character set. Tractor paper feed in widths to 9.8" with RS-232C input port standard.
- Monochrom display monitor (12" diagonal cathode ray tube) of 24 lines with 80 characters per line.
- Z 80 board with 16K to use CP/M based software

General Systems Software

- Disk Operating System (DOS)
- Basic language interpteter (i.e., Microsoft with

----

* Programs implemented in ROM micro-code are considered hardware features rather than described under General Systems Software.

floating point 9 digit arithmetic).

- Fortran language compiler with single precision floating point and half-word integer arithmetic
- Pascal compiler of the International Standards Organization (ISO) UCSD version.
- VisiCalc Calculator/spread sheet functions for tabular reports upto 63 columns and 254 rows.
- Disk utility pack containing programs to update existing diskettes, chain programs together and Disk Operating System (DOS) resident backup.

Technical Reference Manuals

- Integer Basic Programming Manual
- Basic Reference Manual
- 6500 Micro-processor Hardware Manual
- 6500 Micro-processor Programming Manual
- Disk Reference Manual
- Pascal Reference Manual
- VisiCalc Users Guide

Alternative II
IBM Personal Computer
International Business Machines Inc.
White Plains, New York

General Systems Hardware

High-performance micro-processor with 40K bytes of Read Only Memory (ROM) and 256K bytes of Random Access Memory (RAM) for user programs. Intel 8088 micro-processor chip with 4,77 Mhz clock, 250ns memory access time, 410ns cycle time with parity checking. System unit should include:

- Enhanced version of Microsoft BASIC 80 interpreter (contained in ROM)
  - Select 40 or 80 character display lines
  - Full screen editor for program creating and modification
  - Automatic line numbering
  - 40-character variables (all characters significant)
  - Multiple statements per program line
  - 250 characters per program line
  - Comments on program lines
  - Up to 17 digit numeric precision
  - Sequential cassette file support
  - Addressable work space to 60K
  - Integer/real/string variables
  - Single and double precision floating point decimal numbers

- Operating power 65 watt maximum at 220/240v, 50/60 Hz
- Attachment for a customer-supplied cassette recorder for loading and saving programs and data
- ASCII typewriter-style keyboard 83-key keyboard with upper/lower case alphabets
- two 5.25" 160KB diskette drives inside the system unit
- Asynchronous (start-stop) ASCII communications port
- Monochrome display (9" diagonal cathode ray tube) with 25 lines of 80 characters
- Adapter for 80 CPS matrix printer (RS-232C port standard)
- Medium speed impact printer 80 X 132 dot matrix (5 X 7) characters per line at 60 characters per second speed. Full ASCII 64 character set. Tractor paper feed in widths to 9.8" with RS-232C port standard.

General Systems Software

- CP/M Operating System
- EDLIN text editor for file and program preparation

- Basic language interpteter (i.e., Mocrosoft with floating point 9 digit arithmetic).
- Pascal compiler of the International Standards Organization (ISO) UCSD version.
- VisiCalc Calculator/sptead sheet functions for tabular reports upto 63 columns and 254 rows.
- Disk utility pack containing programs to update existing diskettes, chain programs together and Disk Operating System (DOS) resident backup.

Technical Reference Manuals

- Microsoft Basic Manual
- DOS Commands and Reference Manual
- Pascal Reference Manual
- VisiCalc Users Guide
- EDLIN Text Editor Manual

Number	Hardware/Software Description	Retail Price
5150001	System Unit (16KB) with Keyboard	$1,265
5150013	System Unit (48KB) with Keyboard, Diskette Drive, and Drive Adapter	$2,235
5151001	Monochrome Display	$345
5152001	Matrix Printer (eighty-c.p.s.)	$755
1504900	Monochrome Display and Printer Adapter	$335
1505200	Printer Adapter	$150
1501001	16KB Memory Extension Kit	$90
1501011	32KB Memory Expansion Option	$325
1501012	64KB Memory Expansion Option	$540
1503780	5 1/4-inch Diskette Drive Adapter	$220
1503780	5 1/4-inch Diskette Drive	$570
1502074	Asynchronous Communications Adapter	$150
1525614	Printer Stand	$55
1525612	Printer Cable	$55
1501100	Keyboard	$55
6025077	Advanced Diagnostics Package	$155
6024001	DOS and BASIC Extension	$40
6024010	Pascal Compiler	$300
6024032	Asynchronous Communications Support	$40
6024004	VisiCalc	$200
6024005	EASYWRITER	$175
6024008	General Ledger by Peachtree Software Inc.	$595
6024009	Accounts Receivable by Peachtree Software Inc.	$595
6024007	Accounts Payable by Peachtree Software Inc.	$595

Figure 6.2 - Price Schedule for IBM Personal Computer Hardware and Software

Alternative III
System 2600
Vector Graphic Inc.
Westlake Village, California

General Systems Hardware

High-performance micro-processor employing ZCB Z-80 chip architecture with 56K semiconductor memory. bytes of Random Access Memory (RAM), cassette interface, and I/O port connections to include:

- 158 instruction set with memory to memory block transfer and I/O block transfer
- 16-bit arithmetic
- ASCII typewriter-style keyboard 83-key keyboard with upper case alphabet and enhancements for lower case
- Operating power 220/240v, 50/60 Hz
- Floppy disk subsystem:
    - Random/sequential access method disk with arbitrary record lengths
    - 116K byte disk capacity (formatted) or soft-sectored (143K bytes with Pascal)
    - Controler unit interface card
    - Floppy disk interface card
    - Bootstrap program in ROM for loading disks
    - Connecting cables
- Medium speed inpact printer 80 X 132 dot matrix chatacters (5 X 7) per line at 60 characters per second speed, full ASCII 64 character set. Tractor paper feed in widths to 9.8" with RS-232C input port standard.
- Monochrome display monitor (12" diagonal cathode ray tube) of 24 lines with 80 characters per line.

General Systems Software

- Control Program/Monitor (CP/M) operating sytems
- Screen Oriented Program Editor SCOPE
- Z-80 Assembler
- Basic language interpteter (i.e., Mocrosoft with floating point 9 digit arithmetic)
- Fortran language compiler with single precision floating point and half-word integer arithmetic
- Pascal compiler of the International Standards Organization (ISO) UCSD version
- VisiCalc Calculator/spread sheet functions for tabular reports up to 63 columns and 254 rows
- Disk utility pack containing programs to update existing diskettes, chain programs together and Disk

Operating System (DOS) resident backup

Technical Reference Manuals

- Integer Basic Programming Manual
- Basic Reference Manual
- Z-80 Micro-processor Hardware Manual
- Z-80 Micro-processor Programming Manual
- Disk Reference Manual
- Pascal Reference Manual
- VisiCalc Users Guide

Hardware/Software Description	Retail Price
Vector Intelligent Partner	$3,995
Unistor (add-on) floppy disk for VIP's with single-sided drive)	845
Dot matrix 80/120 C.P.S printer	1,000
Statpak statistics package	$500
Execuplan Video calculator	$150
CCA Data Management System	$185
Microsoft Fortran	$400
Microsoft BASIC	$350
Intersystems Pascal	$395

Figure 6.3 - Price Schedule for Vector Graphic Computer Hardware and Software

Specifications for Programmable Calculator
Hewlett-Packard HP-41CV
Hewlett-Packard Inc.
Corvallis, Oregon

General Systems Hardware

High-performance hand-held programmable calculator.

- Basic calculator memory capacity of 2,000 program steps (key-strokes) with "continuous" memory.
- 100 data storage register capacity with programmable statistical registers.
- Arithmetic conventions include scientific, integer, and engineering notation. Arithmetic functions should allow decimal and octal numbering conventions. Trigonometric functions should accept degree-minute-second, decimal degree, radian and gradian measures.
- Arithmetic operations performed in Reverse Polish Notation (RPN). Infix operations or parenthetical notation not acceptable. Functions and program branching logic must have indirect addressing options.
- Alphameric display and editing. Display register must accept a minimum of 12 symbols to label output variables and prompt for user inputs.
- Hardware functions to include:
  - +, -, X, and /.
  - $\sum$, $1/x$, $\sqrt{\ }$, y^x , and ! .
  - Absolute value
  - Trigonometric functions with inverses (SINE, COSINE, and TANGENT). Functions must accept arguments in degree, radian or gradian.
  - Time conversions (degree-minute-second to decimal).
  - Factorials
  - Logarithms (base 10 and e)
  - Octal arithmetic
  - Arithmetic comparisons (X§Y, X=Y, X=Y, and X=0)
  - Boolean logic comparisons (true and false)

- Hardware power must be standard alkaline batteries or rechargable "NiCad" pack batteries using 110V AC input.
- Peripherals must include:

  - Magnetic card reader capable of recording programs, data register values and hardware status flags. Magnetic cards should have optional protection from accidental re-writing or recording. Card reader must allow for the duplication of other cards.

  - Line printer should allow for program trace,

manual and program dump modes. Plotting functions should permit two-variable graphing with user specified graphic character sets.
- Optical bar-code reader for low-cost program publication.

General System Software

- Statistic programs - basic statistics for two variables, analysis of variance, curve fitting (regression analysis), nominal/non-parametric measures (chi-square, contingency tables), and distribution functions (normal, inverse normal and chi-square).
- Financial programs - compound interest, internal rate of return, net present value, loan amortization schedules, depreciation (straight line, declining balance, sum-of-the-year's digits), and bonds.

Technical Reference Manuals

- Owner's Handbook and Programming Guide (HP 00041-90313)
- Operating Manual: A Guide for the Experienced User (HP 00041-90328)
- Standard Applications (HP 00041-90018)
- Stat Pack (HP 00041-90030)
- Financial Decisions Pac (HP 00041-90354)
- Printer Owner's Manual (HP 82143-90001)
- Wand Owner's Manual (HP 82153-90001)
- Card Reader Owner's Handbook (HP 82104-90001)

EQUIPMENT/SUPPLY ITEM DESCRIPTION	UNIT COST	ESTIMATED QUANTITY	TOTAL COST	USER
HP 41CV Programmable Calculator	300	40	12,000	HUDCO WORKSHOP
Magnetic Card Reader (HP 82104A)	200	5	1,000	HUDCO R&D
Printer (HP 82143A)	350	2	700	HUDCO R&D
Optical Reader (HP 82153A)	100	2	200	HUDCO R&D
Statistic PAC I (HP 00041-14003)	30	5	50	HUDCO R&D
Financial PAC (HP 00041-14003)	30	5	150	HUDCO R&D
Magnetic Card Packs (4/box)	45	5	225	HUDCO R&D
Thermal Printer Paper (6/box)	10	10	100	HUDCO R&D

Figure 6.3 - Estimated Cost/Quantities for HP-41CV Programmable Calculators

APPENDIX 7

PADCO/Bertaud Model User's Guide for the Hewlett Packard HP-41CV Programmable Calculator

The PADCO/Bertaud model for analyzing alternatives in urban project design is a useful tool in defining future HUDCO research and development in residential land optimization. The original model proposed by Alan Bertaud is continuously being improved and has been reported in numerous technical papers. [10]

The technical description that follows shows how to use the 1980 PADCO version (originally implemented on the Hewlett Packard HP-67) on the HP-41CV calculator. With very minor changes to data storage definitions and program label entry points, the model and its write-up can be used as-is. [11]

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[10] The Center for International Training and Research in Urban Development. "A Model for Analyzing Alternatives in Urban Project Design." Washington: The Center for International Training and Research in Urban Development, August, 1978.

Bertaud, Alan. "Model for Analyzing Alternatives in Urban Housing Design." Washington: International Bank for Reconstruction and Development, Draft for staff working paper, July, 1979.

Erbach, Jerry. "Economics of Design Alternatives: The Bertaud/PADCO Model." Washington: Planning and Development Collaborative International, Prepared for the Sixth African Housing Conference, Rabat, Morocco, October, 1970.

[11] Planning and Development Collaborative International. "A Working Manual for the Analysis of Urban Shelter Projects with Programs Designed for the Hewlett Packard 67 Calculators." Washington: Planning and Development Collaborative International, September, 1980.

To use the PADCO/Bertaud program cards for the HP-67 calculators on the newer HP-41CV calculator, follow these steps:

- Attach the card reader to the HP-41CV. With the calculator turned off, insert the magnetic card reader into port 4 making sure that the reader is completely inserted.

- Clear program and data memory. Depress and hold the "CLx/A" button while turning the calculator on. Release the "CLx/A" button and "MEMORY LOST" should display in the annunciator.

- Set the HP-41CV to "USER MODE". Depress the user switch and "USER" should display in the annunciator.

- Define data registers compatable with the HP-67. Following these key-strokes will make the HP-41CV compatable with the older HP-67 storage convention:

KEYSTROKES	DISPLAY
XEQ ALPHA SIZE ALPHA	SIZE ___
026	SIZE 026
	0.0000

- Set the HP-41CV to the last program in memory. Press "Gold Key GTO .. ".

- Insert the PADCO/Betraud program you need. Start with the first card (some programs use 2 cards) of the program and insert side 1 into the reader. The HP-41CV begins translating process as soon as the complete program is read. This may take several seconds. During the translation time, the annunciator shows:

WORKING and then PACKING

- The HP-41CV will prompt for two-track programs with a standard prompt:

RDY kk OF nn

where kk is the next track needed in a total of nn. The program cards can be inserted either track 1 first, or track 2 first. Translation begins after the entire program has been read. Once the program is read and translated, it is ready for execution. Refer to the Hewlett Packard "Card Reader Owner's Handbook" Section 3 entitled "HP-67/HP-97 Compatibility" pages 35 to 46 for details.

How to Input Data into the Model

All program variables used by the model must be stored before the program can be used. Each program has a detailed work sheet that gives the title, algebraic symbol, and data storage register for the value. To load the registers with the appropriate value, use the "STO" and "RCL" buttons, the correspondence between HP-67 and HP-41CV data storage registers are as follows:

HP-67	HP-41CV
Primary registers (10)	R00 through R09
Secondary registers (10)	R10 through R19
A	R20
B	R21
C	R22
D	R23
E	R24
I	R25

Figure 7.1 - Data Register Equivalence Between HP-67 and HP-41CV Calculators

Program I Example

To use Program I "Trade-Offs Between Project Parameters", read in the program card as described above and store the following model values (see page 13 column 1 of the PADCO users manual):

[12]

----

[12] When entering zero values for the various program

REQUIRED KEY-STROKE			ANNUNCIATOR	NOTES
10	STO	00	10.0000	I
25	STO	01	25.0000	N
1	STO	02	1.0000	h
10.0	STO	10	10.0000	e
4.73	STO	11	4.7300	C1
0.00001	STO	12	1.0000 -05	C2
8	STO	13	8.00000	a1
75	STO	14	75.0000	a2
80	STO	15	80.0000	a3
0.00001	STO	16	1.0000 -05	a4
40	STO	17	40.0000	b
0.00001	STO	18	1.0000 -05	y
5	STO	20	5.0000	i
36.8	STO	03	36.8000	p
10	STO	04	10.0000	m1
1	STO	05	1.0000	m2

Figure 7.2 - Example Data Storage for PADCO/Bertaud Program I with the HP-41CV

To use the program after the data is stored, simply use the upper row of keys for program entries A, B, C, D, and E. For program enties a, b, c, d, and e, key the gold key first followed by A, B, C, D, or E. The gold key in "USER" mode simply acts as a switch between upper and lower case program entry names.

----

parameters, use .00001 to avoid division by zero errors.

APPENDIX 8

Example Analysis of Subdivision Layouts

The author, in conjunction with the Urban Dwellings Design Group at Massachusetts Institute of Technology, undertook a brief statistical study of 223 residential layouts. The study tested the interrelations between block and lot dimensions, circulation, density, and the percentages of land in private and public use. The most informative result of the analysis was the strong statistical verification that small lots lead to inherently less efficient subdivision layouts. Decreasing lot area and/or using lots whose proportions approximate squares or have their long axis parallel to the lineal services (i.e., streets, water lines, sewers etc.) will always lead to higher infrastructure costs. It should be noted that these results argue against the widespread belief that decreasing lot area is the best way to make projects affordable. The graphs on pages 11 and 14 indicate that the relationship between unit circulation length and block-lot area is not lineal but a negatively sloping power function where the least efficient infrastructure results from blocks under .5 hectare. Since infrastructure requirements increase as lot sizes decrease, there is a direct cost reduction incentive to maximizing the amount of residential land (i.e. lot size) where possible.

It is recommended that the HUDCO Consultancy undertake two similar studies of the land utilization in typical client projects. The first study should analyze the geometrical properties of block-lot areas, proportions, densities, and unit circulation length. These relationships are largely deterministic in that they are the result of the geomety of design. A second study should associate the quantities of residential support land-uses (i.e., area for schools, markets, recreation, etc.) with increasing densities. The results of the second study will be probabilistic rather than deterministic because local building codes and existing off-site land-uses will induce wide variation in project samples. Summary regression curves should be computed to establish the upper limits of residential support areas located on-site. Any project can then be compared to this standard and the project designer/appraiser will know to what extent a proposed design is meeting the requirements.

```
SPSS FOR VM/CMS, VERSION M, RELEASE 8.1, AUGUST 15, 1980

                                        CURRENT DOCUMENTATION FOR THE SPSS BATCH SYSTEM
ORDER FROM MCGRAW-HILL:  SPSS, 2ND ED. (PRINCIPAL TEXT)       ORDER FROM SPSS INC.:  SPSS STATISTICAL ALGORITHMS
                         SPSS PRIMER (BRIEF INTRO TO SPSS)                           SPSS POCKET GUIDE, RELEASE 8
                         SPSS UPDATE (USE W/SPSS,2ND FOR REL. 7 & 8)                 KEYWORDS: THE SPSS INC. NEWSLETTER

DEFAULT SPACE ALLOCATION..     ALLOWS FOR..     51 TRANSFORMATIONS
WORKSPACE      35840 BYTES                     204 RECODE VALUES + LAG VARIABLES
TRANSPACE       5120 BYTES                     822 IF/COMPUTE OPERATIONS

                    1 RUN NAME        URBAN DWELLING ENVIRONMENTS
                    2 FILE NAME       URBAN1
                    3 VARIABLE LIST   ID, TYPE, BLKW, BLKD, BLKA, CL, UCL, LOTW, LOTD, LOTA,
                    4                 LHA, DHA, PPUL, PPRL, DENSITY
                    5 INPUT MEDIUM    DISK
                    6 INPUT FORMAT    FIXED(F3.0,6X,F1.0,2F3.0,F5.3,F3.0,F4.0,1X,2F5.1,F5.0,2F5.1,
                    7                 2F2.0,F4.0,18X)

                     ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

                     VARIABLE  FORMAT  RECORD    COLUMNS

                     ID        F 3. 0       1      1-   3
                     TYPE      F 1. 0       1     10-  10
                     BLKW      F 3. 0       1     11-  13
                     BLKD      F 3. 0       1     14-  16
                     BLKA      F 5. 3       1     17-  21
                     CL        F 3. 0       1     22-  24
                     UCL       F 4. 0       1     25-  28
                     LOTW      F 5. 1       1     30-  34
                     LOTD      F 5. 1       1     35-  39
                     LOTA      F 5. 0       1     40-  44
                     LHA       F 5. 1       1     45-  49
                     DHA       F 5. 1       1     50-  54
                     PPUL      F 2. 0       1     55-  56
                     PPRL      F 2. 0       1     57-  58
                     DENSITY   F 4. 0       1     59-  62

THE INPUT FORMAT PROVIDES FOR  15 VARIABLES.   15 WILL BE READ
IT PROVIDES FOR   1 RECORDS ('CARDS') PER CASE.  A MAXIMUM OF   80 'COLUMNS' ARE USED ON A RECORD.

                    8 MISSING VALUES ID, TYPE, BLKW, BLKD, BLKA, CL, UCL, LOTW, LOTD, LOTA,
                    9                LHA, PPUL, PPRL, DENSITY (0)
                   10 N OF CASES     223
                   11 VALUE LABELS   TYPE (1) GRID (2) GRIDIRON (3) RURAL (4) WATER
                   12 VAR LABELS     ID, ID/
                   13                TYPE, LAYOUT TYPE/
                   14                BLKW, BLOCK WIDTH/
                   15                BLKD, BLOCK DEPTH/
                   16                BLKA, BLOCK AREA/
```

```
                        CL, CIRCULATION LENGTH/
                        UCL, UNIT CIRCULATION LENGTH/
                        LOTW, LOT WIDTH/
                        LOTD, LOT DEPTH/
                        LOTA, LOT AREA/
                        LHA, LOTS PER HA/
                        DHA, DWELLINGS PER HA/
                        PPUL, % PUBLIC LAND/
                        PPRL, % PRIVATE LAND/
                        DENSITY, GROSS DENSITY
   IF                   (BLKA EQ 0) BLKA = BLKW * BLKD
   CONDESCRIPTIVE       ALL

***** GIVEN WORKSPACE ALLOWS FOR  716 VARIABLES FOR CONDESCRIPTIVE PROBLEM *****

   OPTIONS              ALL
OPTIONS ALL IS UNDEFINED...IGNORED
   STATISTICS           ALL
   READ INPUT DATA
```

FILE URBAN1 (CREATION DATE = 10/29/81)

VARIABLE ID ID

MEAN	112.000	STD ERROR	4.320	STD DEV	64.519
VARIANCE	4162.667	KURTOSIS	-1.200	SKEWNESS	0.000
RANGE	222.000	MINIMUM	1.000	MAXIMUM	223.000
SUM	24976.000				

VALID OBSERVATIONS - 223 MISSING OBSERVATIONS - 0

- -

VARIABLE TYPE LAYOUT TYPE

MEAN	1.811	STD ERROR	0.034	STD DEV	0.475
VARIANCE	0.226	KURTOSIS	2.117	SKEWNESS	-0.230
RANGE	3.000	MINIMUM	1.000	MAXIMUM	4.000
SUM	355.000				

VALID OBSERVATIONS - 196 MISSING OBSERVATIONS - 27

- -

VARIABLE BLKW BLOCK WIDTH

MEAN	63.437	STD ERROR	2.654	STD DEV	29.792
VARIANCE	887.576	KURTOSIS	1.890	SKEWNESS	1.268
RANGE	158.000	MINIMUM	14.000	MAXIMUM	172.000
SUM	7993.000				

VALID OBSERVATIONS - 126 MISSING OBSERVATIONS - 97

- -

VARIABLE BLKD BLOCK DEPTH

MEAN	138.079	STD ERROR	5.239	STD DEV	58.803
VARIANCE	3457.802	KURTOSIS	2.350	SKEWNESS	1.211
RANGE	316.000	MINIMUM	40.000	MAXIMUM	356.000
SUM	17398.000				

VALID OBSERVATIONS - 126 MISSING OBSERVATIONS - 97

- -

FILE URBAN1 (CREATION DATE = 10/29/81)

VARIABLE BLKA BLOCK AREA

MEAN	0.918	STD ERROR	0.055	STD DEV	0.664
VARIANCE	0.441	KURTOSIS	3.806	SKEWNESS	1.730
RANGE	3.913	MINIMUM	0.087	MAXIMUM	4.000
SUM	132.139				

VALID OBSERVATIONS - 144 MISSING OBSERVATIONS - 79

- -

VARIABLE CL CIRCULATION LENGTH

MEAN	228.282	STD ERROR	10.374	STD DEV	123.618
VARIANCE	15281.523	KURTOSIS	10.164	SKEWNESS	2.541
RANGE	933.000	MINIMUM	35.000	MAXIMUM	968.000
SUM	32416.000				

VALID OBSERVATIONS - 142 MISSING OBSERVATIONS - 81

- -

VARIABLE UCL UNIT CIRCULATION LENGTH

MEAN	308.639	STD ERROR	12.940	STD DEV	156.892
VARIANCE	24615.081	KURTOSIS	5.326	SKEWNESS	1.862
RANGE	1052.000	MINIMUM	20.000	MAXIMUM	1072.000
SUM	45370.000				

VALID OBSERVATIONS - 147 MISSING OBSERVATIONS - 76

- -

VARIABLE LOTW LOT WIDTH

MEAN	11.024	STD ERROR	1.019	STD DEV	9.116
VARIANCE	83.100	KURTOSIS	22.329	SKEWNESS	4.000
RANGE	67.000	MINIMUM	3.000	MAXIMUM	70.000
SUM	881.900				

VALID OBSERVATIONS - 80 MISSING OBSERVATIONS - 143

- -

FILE URBAN1 (CREATION DATE = 10/29/81)

VARIABLE LOTD LOT DEPTH

MEAN	22.522	STD ERROR	2.923	STD DEV	26.146
VARIANCE	683.602	KURTOSIS	62.350	SKEWNESS	7.500
RANGE	235.000	MINIMUM	5.000	MAXIMUM	240.000
SUM	1801.800				

VALID OBSERVATIONS - 80 MISSING OBSERVATIONS - 143

- -

VARIABLE LOTA LOT AREA

MEAN	424.435	STD ERROR	157.190	STD DEV	1633.564
VARIANCE	**********	KURTOSIS	96.777	SKEWNESS	9.625
RANGE	16780.000	MINIMUM	20.000	MAXIMUM	16800.000
SUM	45839.000				

VALID OBSERVATIONS - 108 MISSING OBSERVATIONS - 115

- -

VARIABLE LHA LOTS PER HA

MEAN	48.161	STD ERROR	3.984	STD DEV	45.079
VARIANCE	2032.094	KURTOSIS	10.981	SKEWNESS	2.691
RANGE	319.400	MINIMUM	0.600	MAXIMUM	320.000
SUM	6164.600				

VALID OBSERVATIONS - 128 MISSING OBSERVATIONS - 95

- -

VARIABLE DHA DWELLINGS PER HA

MEAN	65.014	STD ERROR	6.105	STD DEV	91.171
VARIANCE	8312.111	KURTOSIS	11.030	SKEWNESS	2.838
RANGE	639.000	MINIMUM	0.0	MAXIMUM	639.000
SUM	14498.100				

VALID OBSERVATIONS - 223 MISSING OBSERVATIONS - 0

- -

FILE URBAN1 (CREATION DATE = 10/29/81)

VARIABLE PPUL % PUBLIC LAND

MEAN	34.372	STD ERROR	1.589	STD DEV	20.351
VARIANCE	414.174	KURTOSIS	0.334	SKEWNESS	1.100
RANGE	87.000	MINIMUM	4.000	MAXIMUM	91.000
SUM	5637.000				

VALID OBSERVATIONS - 164 MISSING OBSERVATIONS - 59

- -

VARIABLE PPRL % PRIVATE LAND

MEAN	64.823	STD ERROR	1.624	STD DEV	20.803
VARIANCE	432.760	KURTOSIS	0.237	SKEWNESS	-1.072
RANGE	87.000	MINIMUM	9.000	MAXIMUM	96.000
SUM	10631.000				

VALID OBSERVATIONS - 164 MISSING OBSERVATIONS - 59

- -

VARIABLE DENSITY GROSS DENSITY

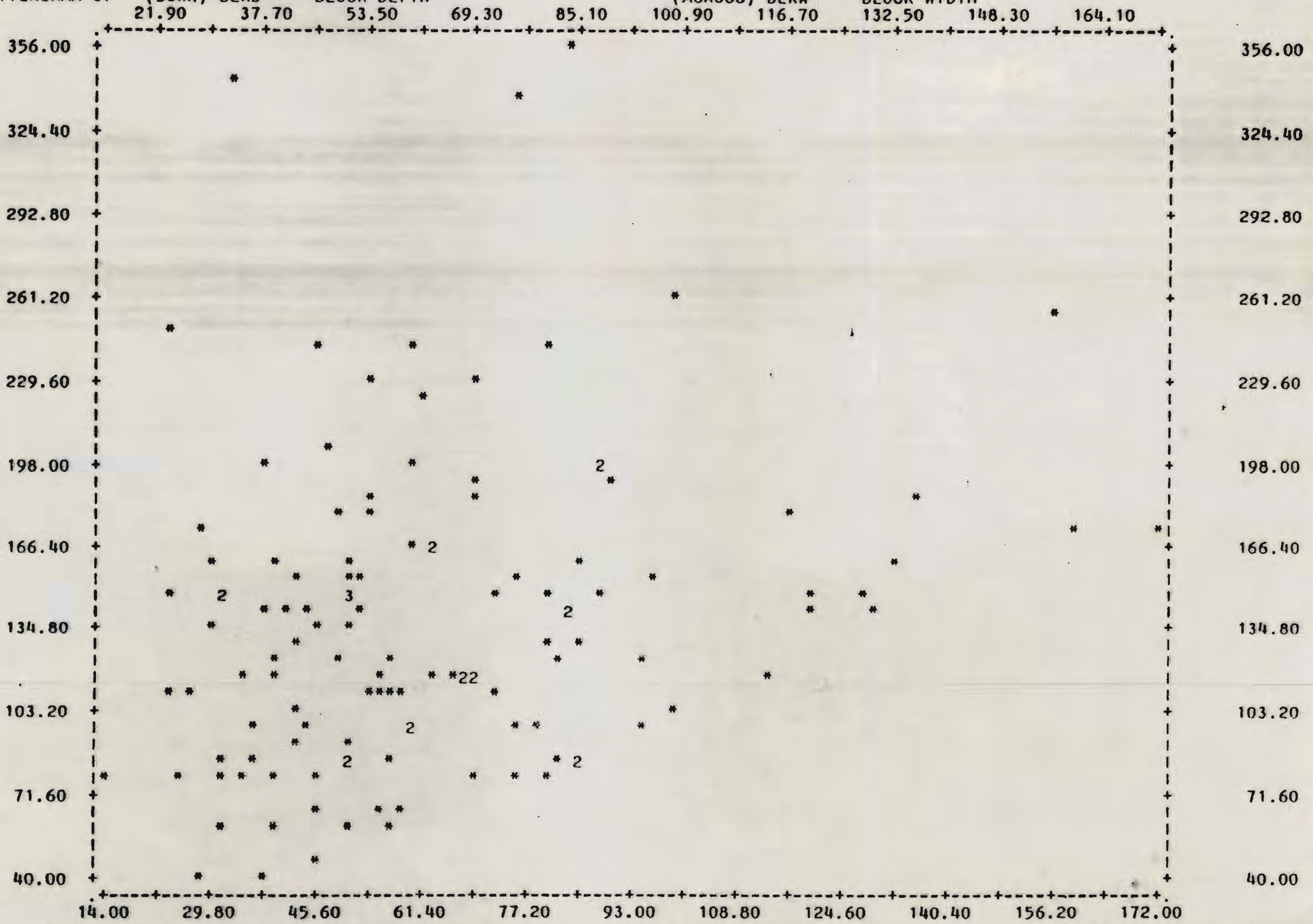
MEAN	484.132	STD ERROR	38.956	STD DEV	491.213
VARIANCE	241290.495	KURTOSIS	8.529	SKEWNESS	2.556
RANGE	3193.000	MINIMUM	2.000	MAXIMUM	3195.000
SUM	76977.000				

VALID OBSERVATIONS - 159 MISSING OBSERVATIONS - 64

```
TRANSPACE REQUIRED..       100 BYTES
       1 TRANSFORMATIONS
       0 RECODE VALUES + LAG VARIABLES
       6 IF/COMPUTE OPERATIONS

CPU TIME REQUIRED..    1.47 SECONDS


                    32 SCATTERGRAM      BLKD WITH BLKW
                    33 OPTIONS          2,4
                    34 STATISTICS       ALL

***** GIVEN WORKSPACE ALLOWS FOR   2985 CASES FOR SCATTERGRAM PROBLEM *****
```

URBAN DWELLING ENVIRONMENTS 10/29/81 PAGE 8

FILE URBAN1 (CREATION DATE = 10/29/81)
SCATTERGRAM OF (DOWN) BLKD BLOCK DEPTH (ACROSS) BLKW BLOCK WIDTH



STATISTICS..

CORRELATION (R)-	0.25131	R SQUARED -	0.06316	SIGNIFICANCE -	0.00227
STD ERR OF EST -	57.14488	INTERCEPT (A) -	106.61261	SLOPE (B) -	0.49604
PLOTTED VALUES -	126	EXCLUDED VALUES-	0	MISSING VALUES -	97

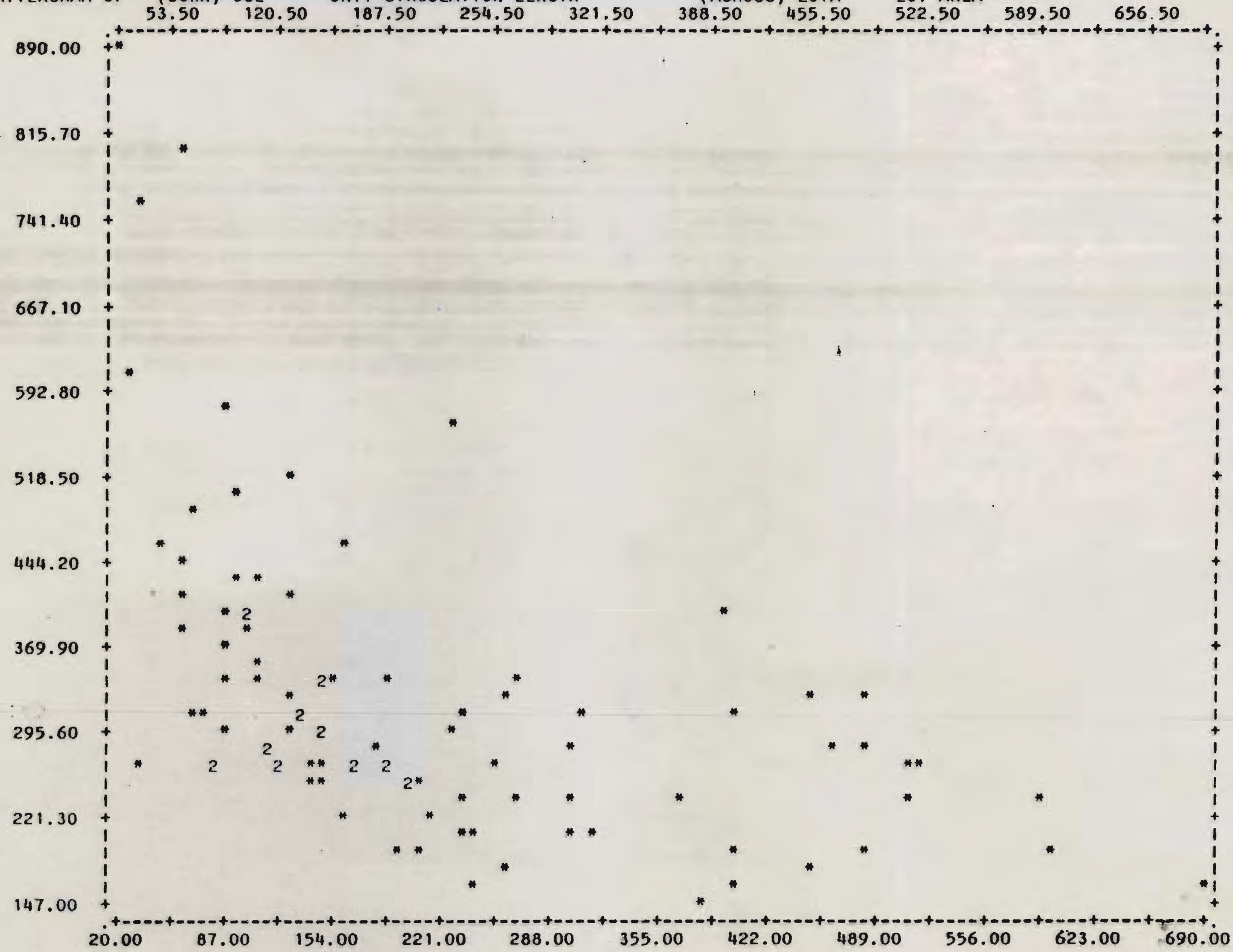
'*********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

CPU TIME REQUIRED.. 0.56 SECONDS

```
35 *IF           (ID EQ 33 OR 41 OR 136 OR 138 OR 198 OR 49 OR 81) UCL = 0
36 SCATTERGRAM   UCL WITH LOTA
37 OPTIONS       2,4
38 STATISTICS    ALL
```

***** GIVEN WORKSPACE ALLOWS FOR 2985 CASES FOR SCATTERGRAM PROBLEM *****

FILE URBAN1 (CREATION DATE = 10/29/81)
SCATTERGRAM OF (DOWN) UCL UNIT CIRCULATION LENGTH (ACROSS) LOTA LOT AREA



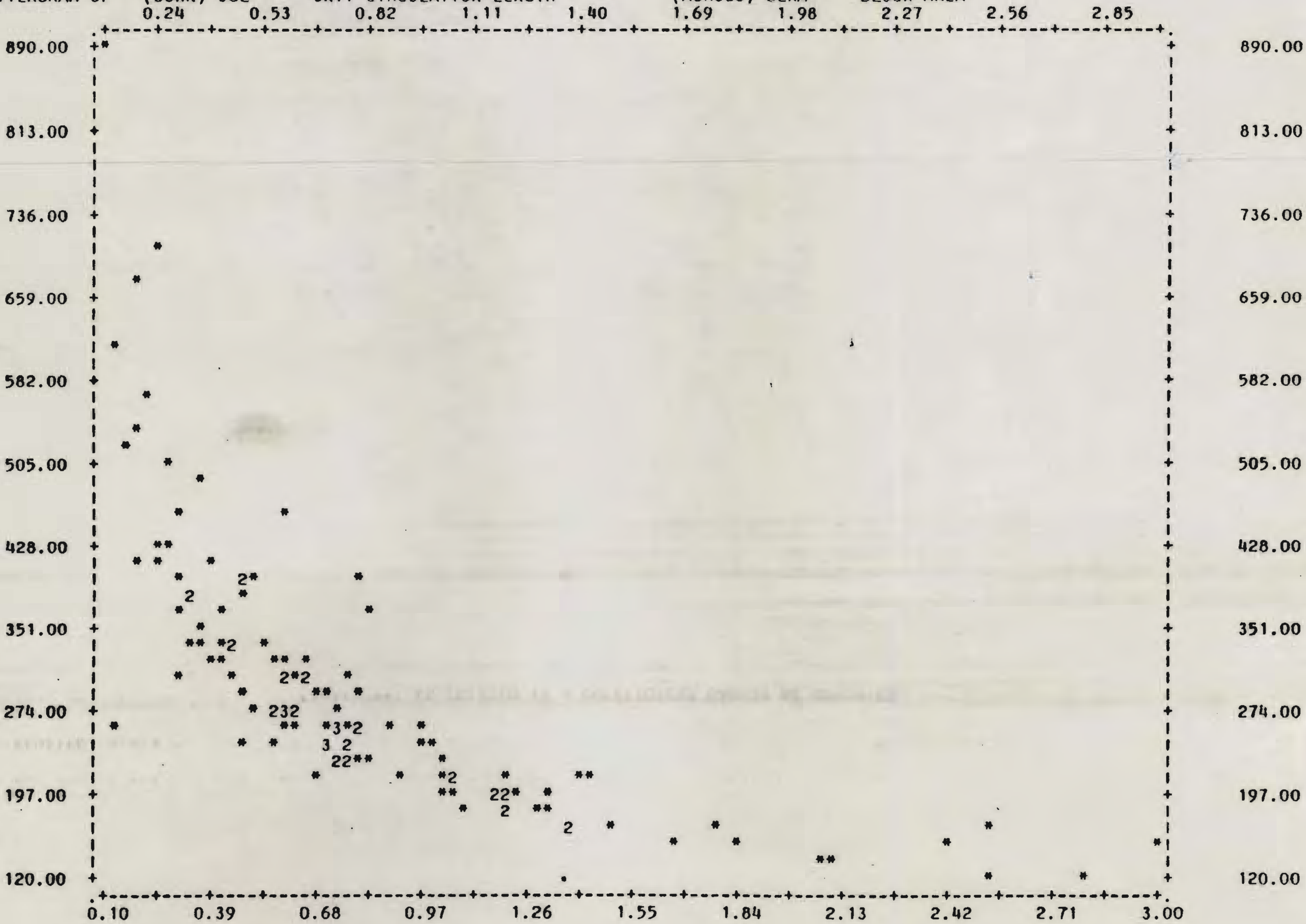
STATISTICS..

CORRELATION (R)-	-0.50240	R SQUARED -	0.25241	SIGNIFICANCE -	0.00000
STD ERR OF EST -	113.82628	INTERCEPT (A) -	414.91928	SLOPE (B) -	-0.44139
PLOTTED VALUES -	95	EXCLUDED VALUES-	0	MISSING VALUES -	128

'*********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

```
TRANSPACE REQUIRED..      192 BYTES
     1 TRANSFORMATIONS
     0 RECODE VALUES + LAG VARIABLES
    29 IF/COMPUTE OPERATIONS

CPU TIME REQUIRED..    0.77 SECONDS


        39 *IF             (ID EQ 12 OR 28 OR 34 OR 35 OR 37 OR 58 OR 87 OR 91 OR 104
        40                 OR 122 OR 126 OR 127 OR 132  OR 144 OR 157 OR 211 OR 177 OR 84)
        41                 UCL = 0
        42 SCATTERGRAM     UCL WITH BLKA
        43 OPTIONS         2,4
        44 STATISTICS      ALL

***** GIVEN WORKSPACE ALLOWS FOR   2985 CASES FOR SCATTERGRAM PROBLEM *****
```

FILE URBAN1 (CREATION DATE = 10/29/81)
SCATTERGRAM OF (DOWN) UCL UNIT CIRCULATION LENGTH (ACROSS) BLKA BLOCK AREA



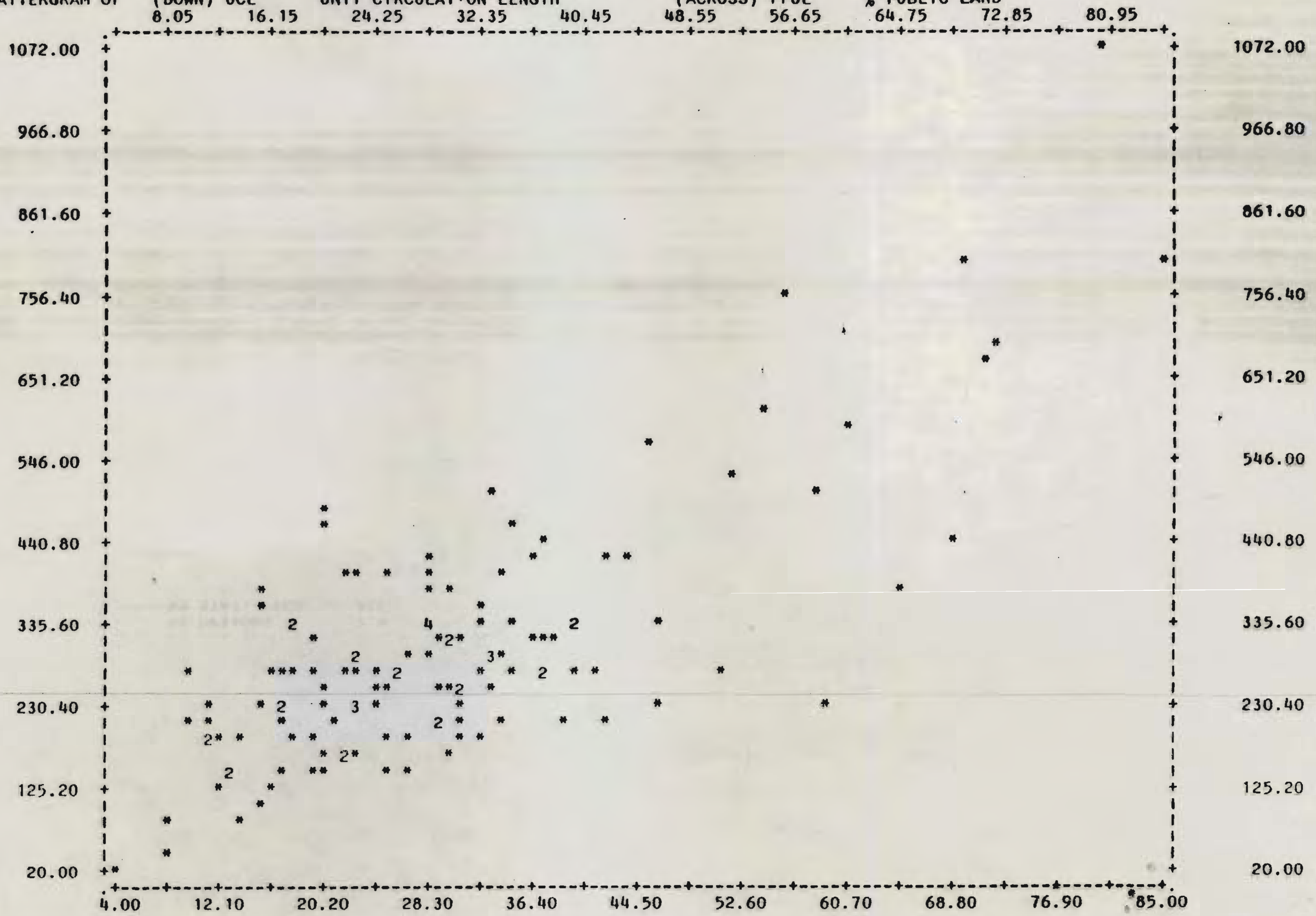
STATISTICS..

CORRELATION (R)-	-0.69630	R SQUARED -	0.48484	SIGNIFICANCE -	0.00000
STD ERR OF EST -	87.76789	INTERCEPT (A) -	416.88495	SLOPE (B) -	-151.48684
PLOTTED VALUES -	122	EXCLUDED VALUES-	0	MISSING VALUES -	101

'*********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

```
TRANSPACE REQUIRED..      468 BYTES
      1 TRANSFORMATIONS
      0 RECODE VALUES + LAG VARIABLES
     73 IF/COMPUTE OPERATIONS

CPU TIME REQUIRED..    1.03 SECONDS


                  45 *IF            (ID EQ 12 OR 27 OR 28 OR 29 OR 56 OR 87 OR 104 OR 144 OR 188)
                  46                UCL = 0
                  47 SCATTERGRAM    UCL WITH PPUL
                  48 OPTIONS        2,4
                  49 STATISTICS     ALL

***** GIVEN WORKSPACE ALLOWS FOR   2985 CASES FOR SCATTERGRAM PROBLEM *****
```

FILE URBAN1 (CREATION DATE = 10/29/81)
SCATTERGRAM OF (DOWN) UCL UNIT CIRCULATION LENGTH (ACROSS) PPUL % PUBLIC LAND



STATISTICS..

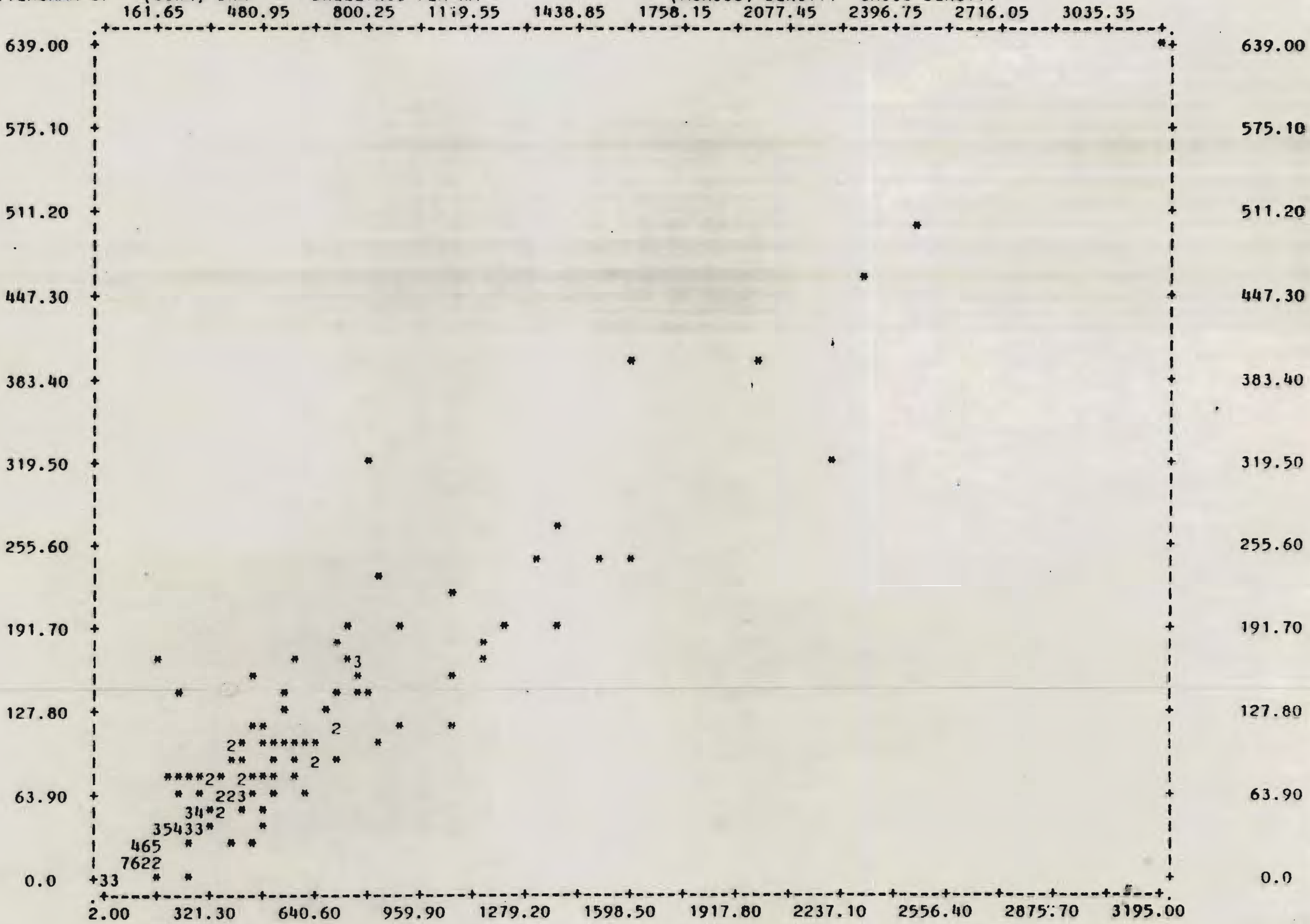
CORRELATION (R)-	0.75155	R SQUARED -	0.56482	SIGNIFICANCE -	0.00000
STD ERR OF EST -	101.39510	INTERCEPT (A) -	75.69128	SLOPE (B) -	7.59513
PLOTTED VALUES -	135	EXCLUDED VALUES-	0	MISSING VALUES -	88

'********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

```
TRANSPACE REQUIRED..       244 BYTES
      1 TRANSFORMATIONS
      0 RECODE VALUES + LAG VARIABLES
     37 IF/COMPUTE OPERATIONS

CPU TIME REQUIRED..    0.85 SECONDS


              50 *IF            (ID EQ 37 EQ 101)DHA = 0
              51 SCATTERGRAM    DHA 'ITH DENSITY
              52 OPTIONS        2,4
              53 STATISTICS     ALL

***** GIVEN WORKSPACE ALLOWS FOR   2985 CASES FOR SCATTERGRAM PROBLEM *****
```

URBAN DWELLING ENVIRONMENTS 10/29/81 PAGE 20

FILE URBAN1 (CREATION DATE = 10/29/81)
SCATTERGRAM OF (DOWN) DHA DWELLINGS PER HA (ACROSS) DENSITY GROSS DENSITY



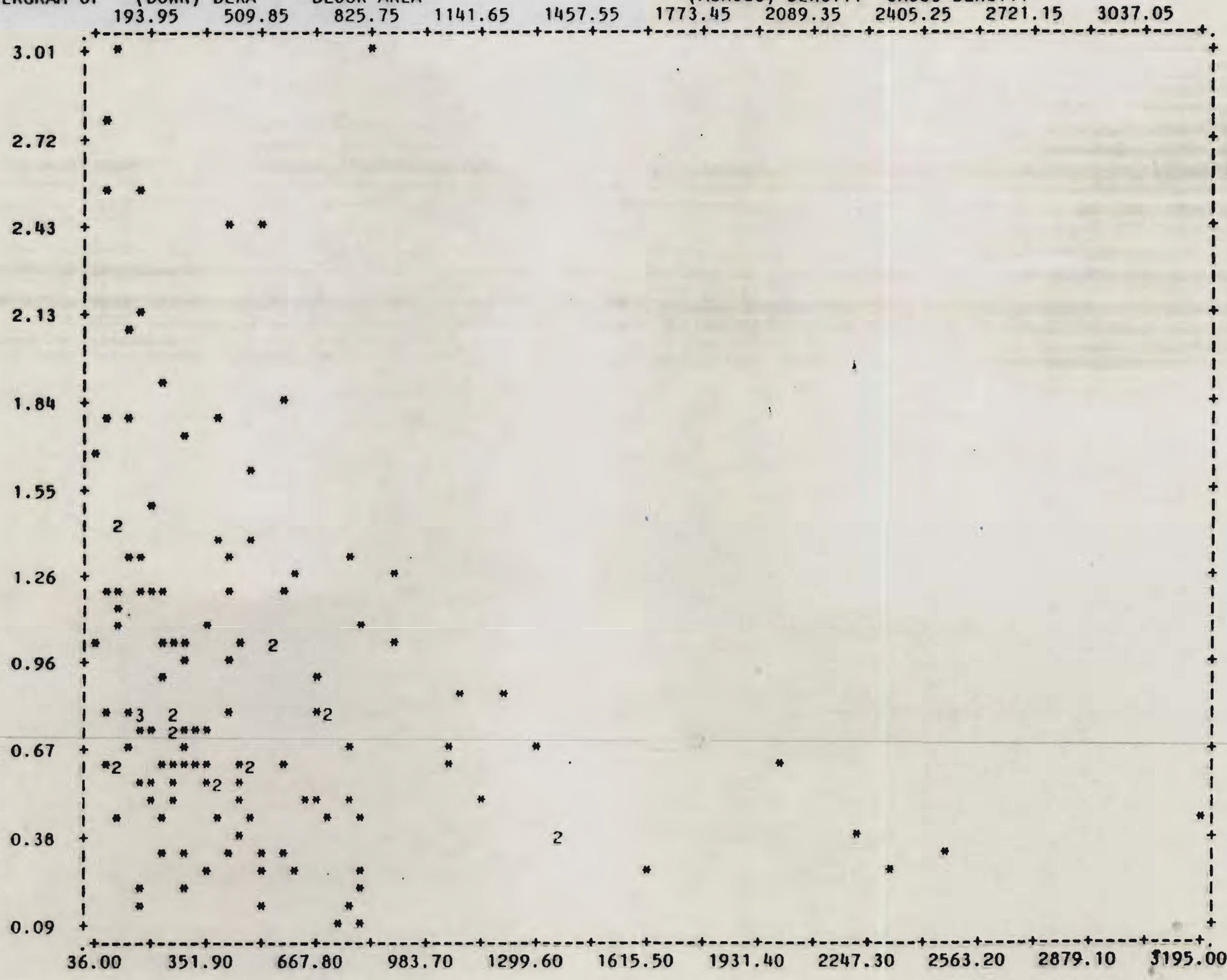
STATISTICS..

CORRELATION (R)-	0.94042	R SQUARED -	0.88439	SIGNIFICANCE -	0.00000
STD ERR OF EST -	33.13527	INTERCEPT (A) -	0.06167	SLOPE (B) -	0.18598
PLOTTED VALUES -	159	EXCLUDED VALUES-	0	MISSING VALUES -	64

'*********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

```
TRANSPACE REQUIRED..      100 BYTES
      1 TRANSFORMATIONS
      0 RECODE VALUES + LAG VARIABLES
      6 IF/COMPUTE OPERATIONS

CPU TIME REQUIRED..    0.72 SECONDS


                 54 *IF              (ID EQ 34) BLKA = 0
                 55 SCATTERGRAM      BLKA WITH DENSITY
                 56 OPTIONS          2,4
                 57 STATISTICS       ALL

***** GIVEN WORKSPACE ALLOWS FOR   2985 CASES FOR SCATTERGRAM PROBLEM *****
```

FILE URBAN1 (CREATION DATE = 10/29/81)
SCATTERGRAM OF (DOWN) BLKA BLOCK AREA (ACROSS) DENSITY GROSS DENSITY



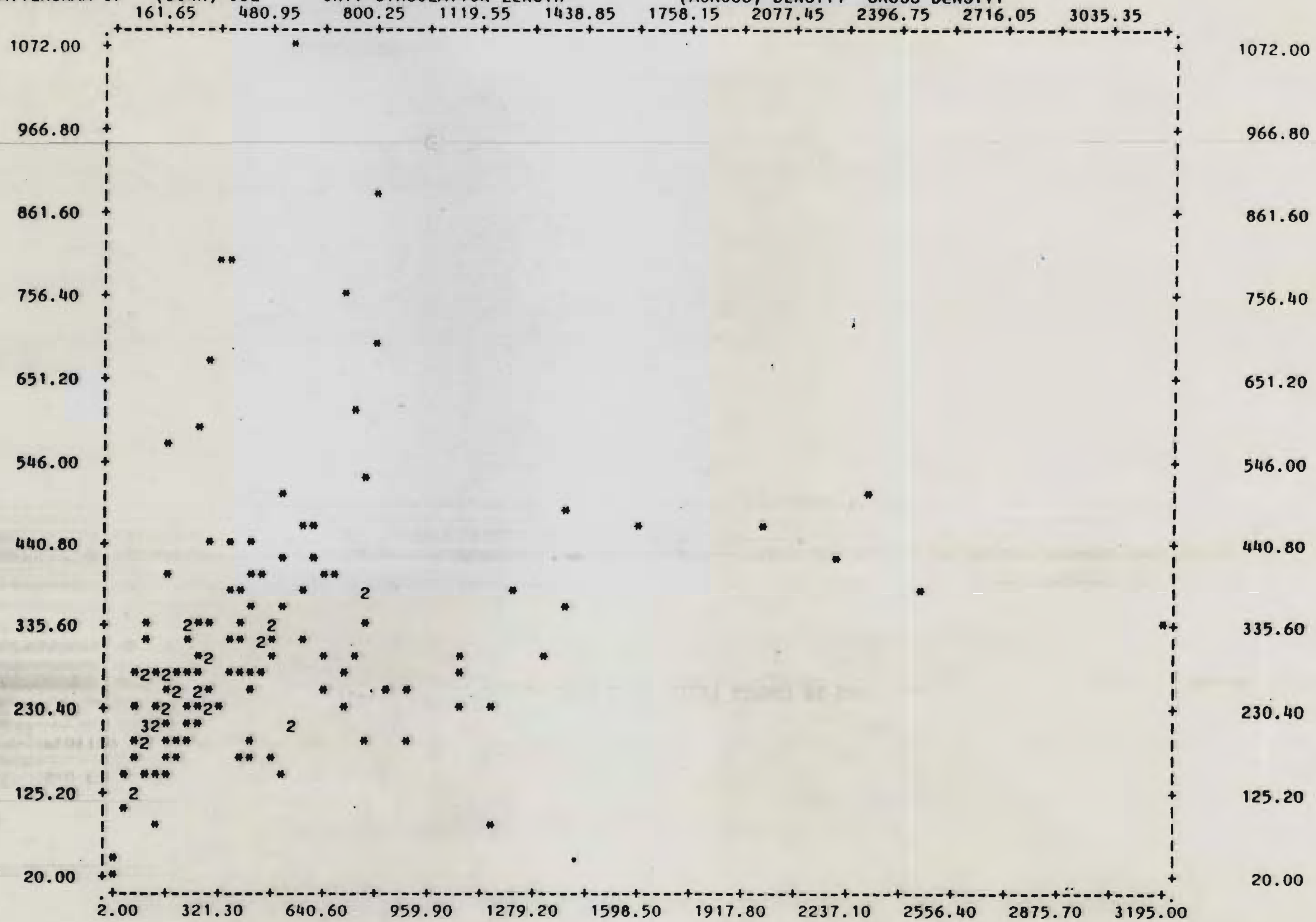
STATISTICS..

CORRELATION (R)-	-0.28826	R SQUARED -	0.08309	SIGNIFICANCE -	0.00035
STD ERR OF EST -	0.58766	INTERCEPT (A) -	1.06948	SLOPE (B) -	-0.00035
PLOTTED VALUES -	135	EXCLUDED VALUES-	0	MISSING VALUES -	88

'*********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

```
TRANSPACE REQUIRED..       100 BYTES
      1 TRANSFORMATIONS
      0 RECODE VALUES + LAG VARIABLES
      5 IF/COMPUTE OPERATIONS

CPU TIME REQUIRED..    0.67 SECONDS


                 58 SCATTERGRAM      UCL WITH DENSITY
                 59 OPTIONS          2,4
                 60 STATISTICS       ALL

***** GIVEN WORKSPACE ALLOWS FOR   2985 CASES FOR SCATTERGRAM PROBLEM *****
```

FILE URBAN1 (CREATION DATE = 10/29/81)
SCATTERGRAM OF (DOWN) UCL UNIT CIRCULATION LENGTH (ACROSS) DENSITY GROSS DENSITY



STATISTICS..

CORRELATION (R)-	0.27260	R SQUARED -	0.07431	SIGNIFICANCE -	0.00058
STD ERR OF EST -	153.98968	INTERCEPT (A) -	269.10580	SLOPE (B) -	0.08708
PLOTTED VALUES -	139	EXCLUDED VALUES-	0	MISSING VALUES -	84

'*********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

```
CPU TIME REQUIRED..     0.54 SECONDS


                 61 FINISH

          USAGE DATA FILE IS EMPTY OR DUMMY
          NOTIFY YOUR SPSS COORDINATOR OF THIS ERROR.

          NORMAL END OF JOB.
             61 CONTROL CARDS WERE PROCESSED.
              0 ERRORS WERE DETECTED.
```

MISSING PAGE

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The following bibliography of Housing and Urban Development Corporation Limited publications were found particularly useful in completing the terms of the mission reported herein. Subsequent missions to HUDCO may find it helpful to review copies filed at the National Savings and Loan League, Washington, D.C.. Further information and additional copies are available from:

Housing and Urban Development
Corporation Limited
12-A Jamnagar House
New Delhi, India
110011

or

Housing and Urban Development Corporation
HUDCO House, Lodi Road
New Delhi, India
110003 (Telegram: HOUSECORP)

Housing and Urban Development Corporation Limited. **Programme Procedures and Guidelines**. New Delhi: Housing and Urban Development Corporation Limited, Second edition, 1980.

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