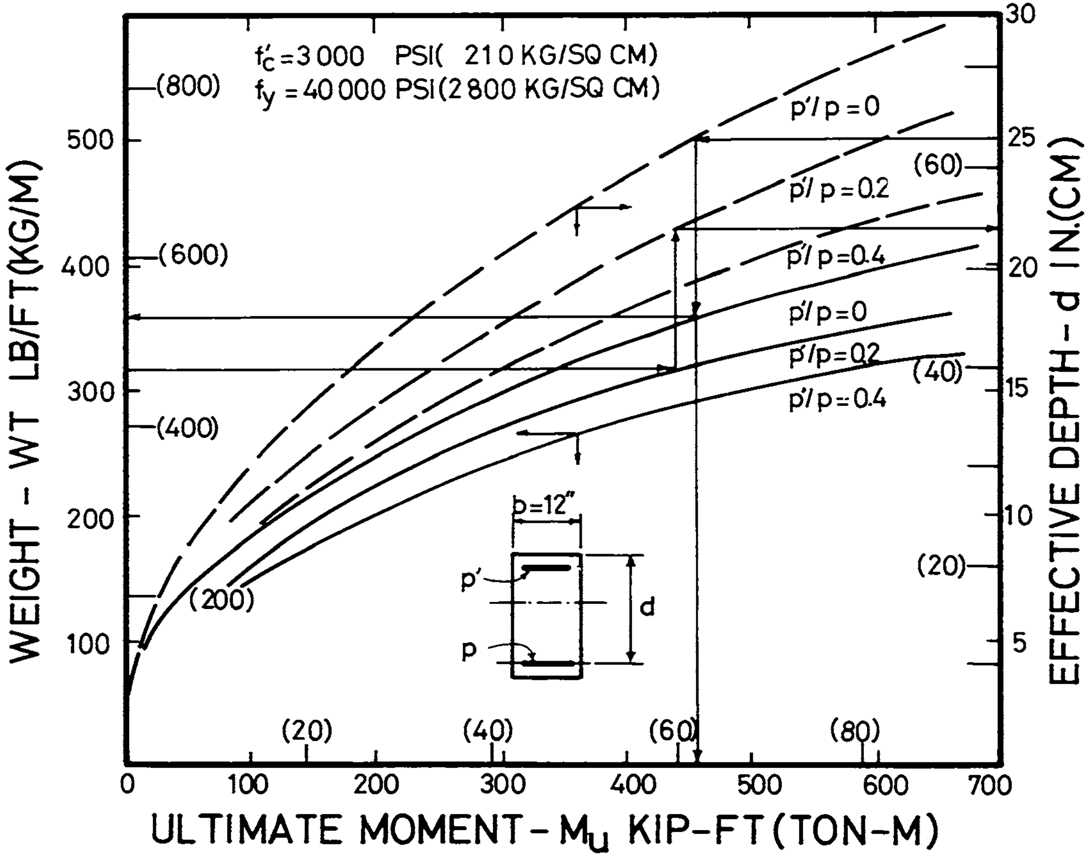

Fig. 2—Optimum properties of rectangular sections

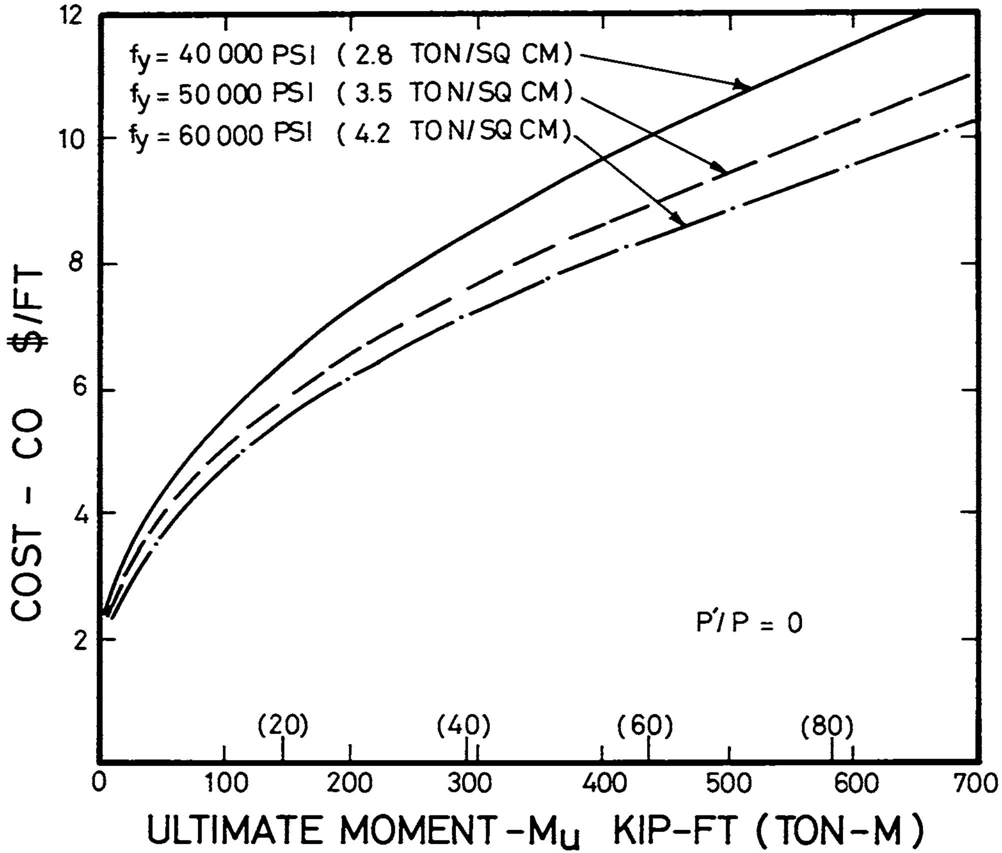

Fig. 3—Optimum cost of rectangular sections

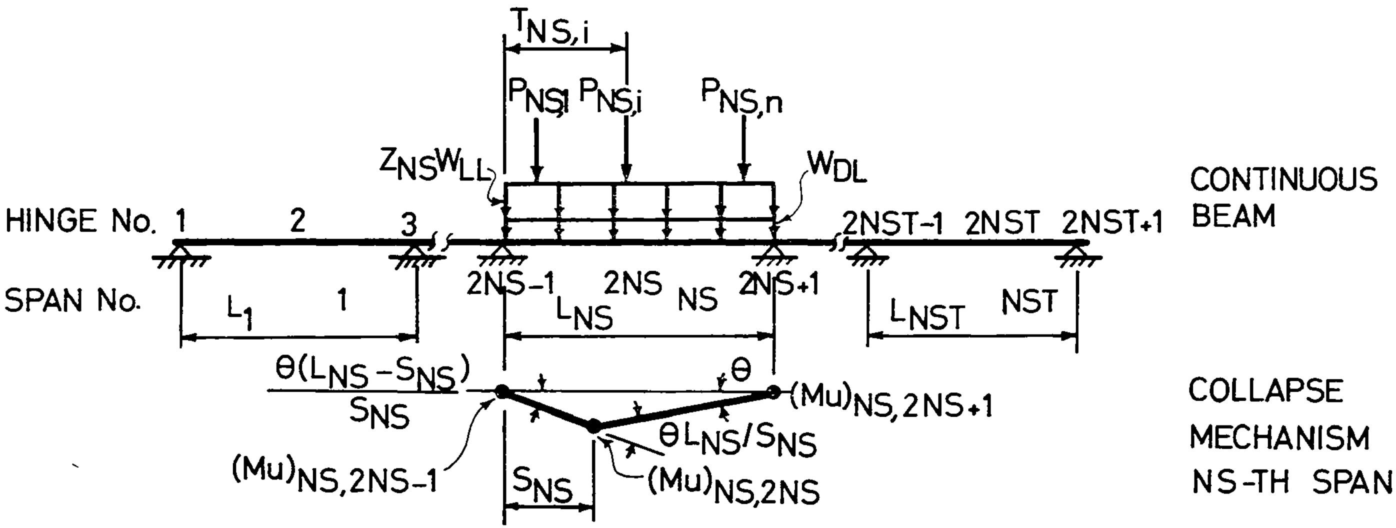

Fig. 4—Plastic behavior at ultimate load

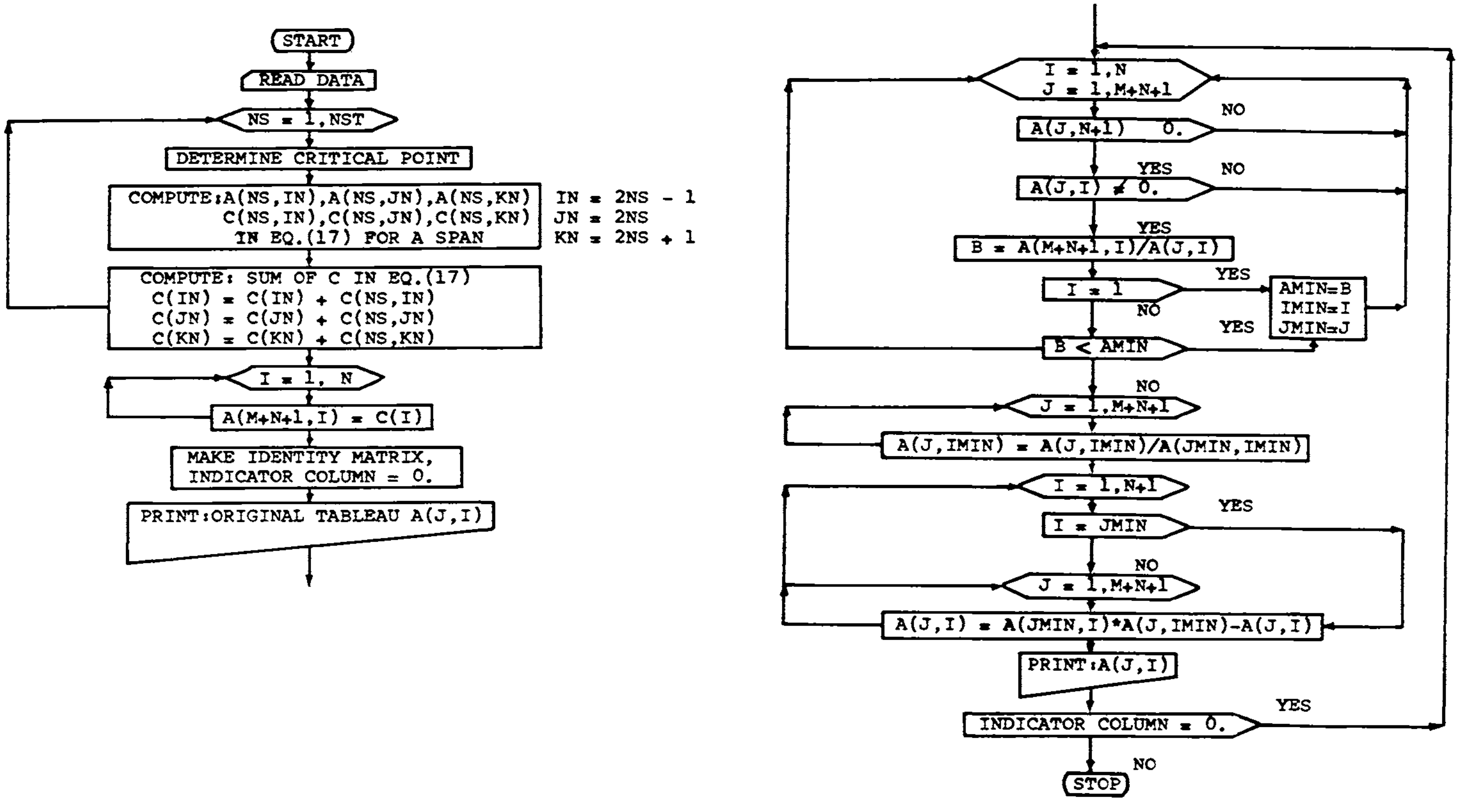

Fig. 5—Flow chart: optimum limit design of continuous beams and slabs

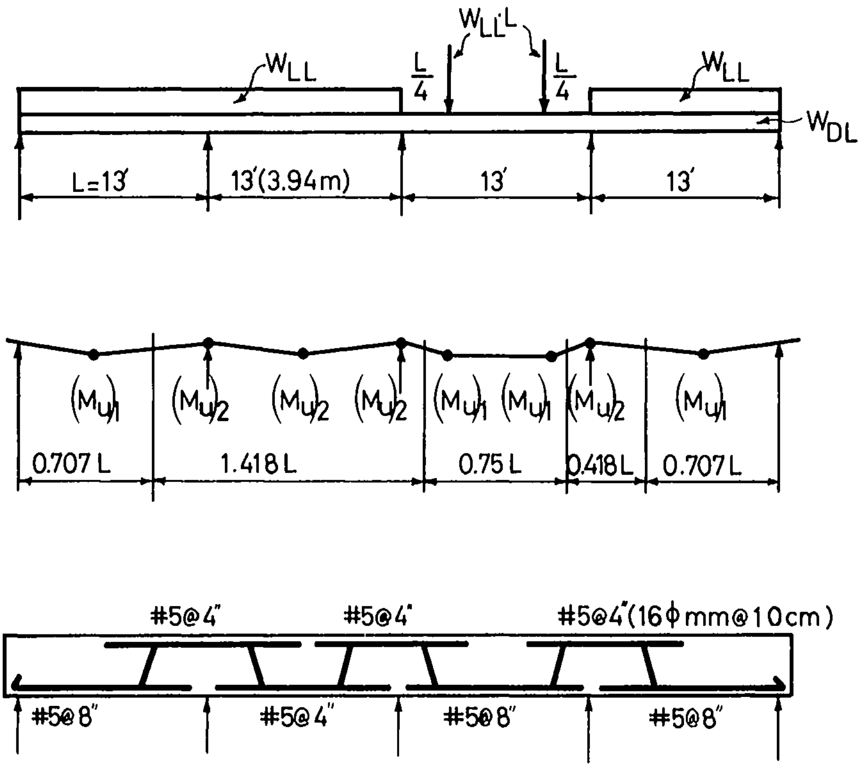

Fig. 6–Slab design problem

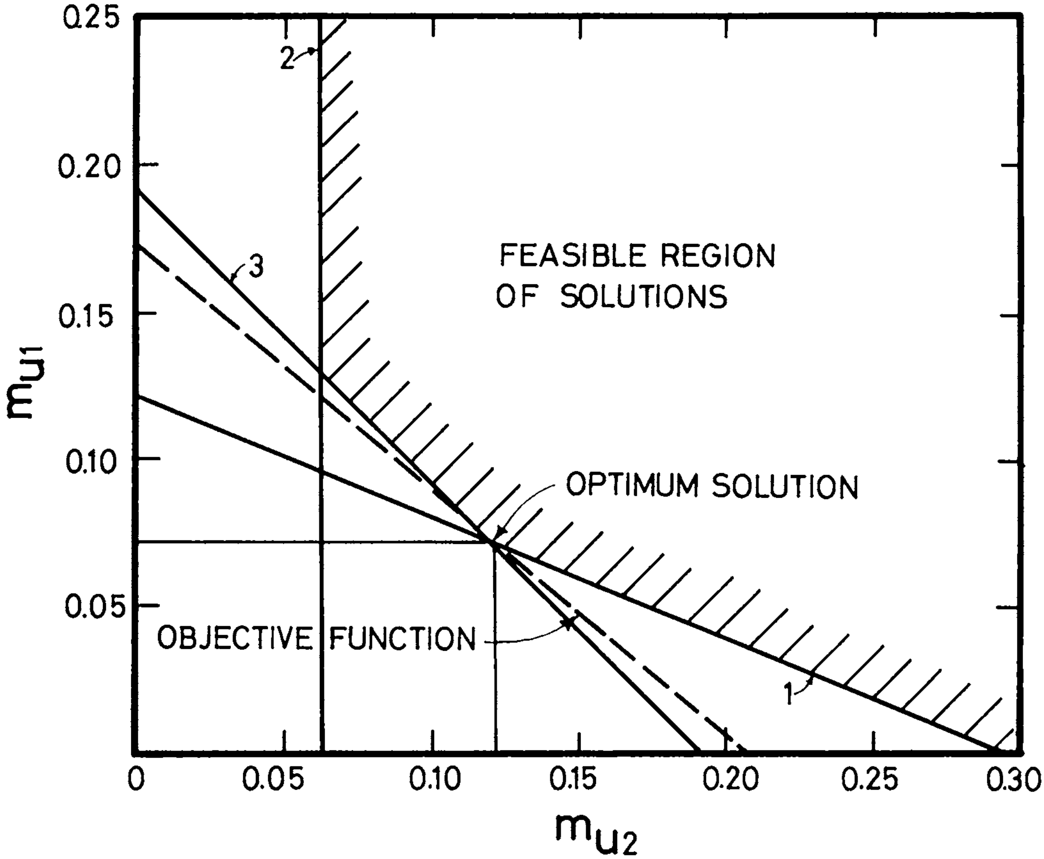

Fig. 7–Optimum solution–slab design

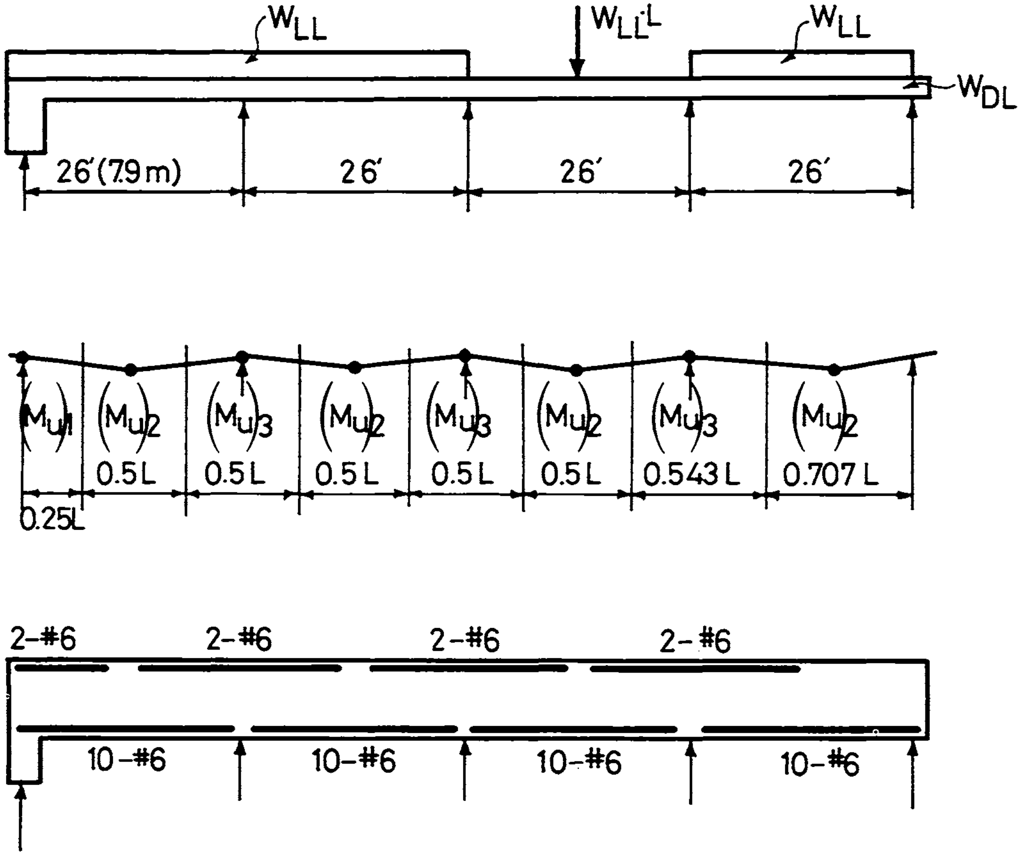

Fig. 8—Beam design problem

INPT DATA FOR BEAM DESIGN

```
4 3 1885. 2340.
0.5000 0.0000 0.0000 0.0000 1.0000
26.00 1 2 3 1.0
0.5000 0.0000 0.0000 0.0000 1.0000
26.00 3 2 3 1.0
0.5000 0.0000 1.0000 0.0000 0.0000
26.00 3 2 3 1.0
0.5860 0.0000 0.0000 0.0000 1.0000
26.00 3 2 0 1.0
```

CONSTRAINTS

```
0.100000E 01 0.200000E 01 0.100000E 01-0.250000E 00

0.000000E 00 0.100000E 01 0.100000E 01-0.125000E 00

0.000000E 00 0.100000E 01 0.100000E 01-0.194229E 00

0.000000E 00 0.100000E 01 0.414000E 00-0.121301E 00
```

OBJECTIVE FUNCTION

```
0.250000E 00 0.220700E 01 0.154300E 01
```

(a) ORIGINAL TABLEAU

```
I=  1
 0.100000E 01 0.200000E 01 0.100000E 01-0.250000E 00

 0.000000E 00 0.100000E 01 0.100000E 01-0.125000E 00

 0.000000E 00 0.100000E 01 0.100000E 01-0.194229E 00

 0.000000E 00 0.100000E 01 0.414000E 00-0.121301E 00

 0.100000E 01 0.000000E 00 0.000000E 00 0.000000E 00

 0.000000E 00 0.100000E 01 0.000000E 00 0.000000E 00

 0.000000E 00 0.000000E 00 0.100000E 01 0.000000E 00

 0.250000E 00 0.220700E 01 0.154300E 01 0.000000E 00
```

Fig. 9—Simplex linear programming tableaux

(b) SECOND TABLEAU

```
I= 2
 0.100000E 01 0.000000E 00 0.000000E 00-0.000000E 00

 0.000000E 00 0.100000E 01 0.100000E 01-0.125000E 00

 0.000000E 00 0.100000E 01 0.100000E 01-0.194229E 00

 0.000000E 00 0.100000E 01 0.414000E 00-0.121301E 00

 0.100000E 01-0.200000E 01-0.100000E 01 0.250000E 00

 0.000000E 00 0.100000E 01 0.000000E 00 0.000000E 00

 0.000000E 00 0.000000E 00 0.100000E 01 0.000000E 00

 0.250000E 00 0.170700E 01 0.129300E 01 0.625000E-01
```

(c) THIRD TABLEAU

```
I= 3
 0.100000E 01 0.000000E 00 0.000000E 00-0.000000E 00

 0.000000E 00 0.000000E 00 0.100000E 01-0.000000E 00

 0.000000E 00 0.000000E 00 0.100000E 01-0.692290E-01

 0.000000E 00 0.586000E 00 0.414000E 00-0.695510E-01

 0.100000E 01-0.100000E 01-0.100000E 01 0.125000E 00

 0.000000E 00 0.100000E 01 0.000000E 00 0.000000E 00

 0.000000E 00-0.100000E 01 0.100000E 01 0.125000E 00

 0.250000E 00 0.414000E 00 0.129300E 01 0.224125E 00
```

(d) FINAL TABLEAU

```
I= 4
 0.100000E 01 0.000000E 00 0.000000E 00-0.000000E 00

 0.000000E 00 0.000000E 00 0.100000E 01-0.000000E 00

 0.000000E 00 0.000000E 00 0.100000E 01-0.692290E-01

 0.000000E 00 0.100000E 01 0.000000E 00-0.000000E 00

 0.100000E 01-0.170648E 01-0.293517E 00 0.631261E-02

 0.000000E 00 0.170648E 01-0.706482E 00 0.118687E 00

 0.000000E 00-0.170648E 01 0.170648E 01 0.631261E-02

 0.250000E 00 0.706484E 00 0.100051E 01 0.273261E 00
```

Fig. 9—Simplex linear programming tableaux (cont'd.)

PAPER SP33-10

COMPUTERIZED CONCRETE MIX PROPORTIONING FOR LARGE PROJECTS

By V. M. MALHOTRA and P. D. HIBBERT

This paper describes the use of a digital computer in the design of concrete mixes for large construction projects. The salient features of a program called CONMIX are outlined, the nature of input data and output are discussed, and a flow chart of the program is included. The basis of the program is the absolute volume method, using various design tables as given in the latest revision of ACI Standard, "Recommended Practice for Selecting Proportions for Normal-Weight Concrete (ACI 613-54)." The paper is concluded by illustrating the use of the program with three typical examples, and by discussing its field applications.

Keywords: aggregate gradation; aggregate size; coarse aggregates; *computer programs; concretes;* costs; fine aggregates; *mix proportioning;* moisture content; quality control; water-cement ratio.

INTRODUCTION

☐ The use of computers in both the analysis and design of concrete structures has become commonplace during the past decade. One notable field, in which computers have had little or no application, is in the design of concrete mixes and control of quality of concrete for either small or large projects. The recent publication of several papers indicates the increased use of computers in the control of quality of concrete and statistical analysis of test results[1,2,3,4]; this is encouraging. The limited use of computers in the design of concrete mixes may be due to the fact that mix design is more empirical than mathematically analytical.

In recent years a mix design procedure known as the ACI method of proportioning has gained widespread use in North America. This procedure, described in detail in the latest revision of ACI Standard, "Recommended Practice for Selecting Proportions for Normal Weight Concrete (ACI 613-54)," is partly analytical and partly empirical, but it permits reasonably close calculations of trial mix quantities for a variety of job conditions. In spite of the fact that extensive use is made of tabular data, the method is tedious and time consuming, especially when a large number of concrete mixes are being designed for large projects using various maximum-size aggregates and widely ranging water contents. Constant adjustments in the mix design are necessary because of changes in the grading of fine aggregates and because different transporting, placing and compacting equipment are used.

In order to eliminate this computational drudgery, a computer program called CONMIX, written in FORTRAN IV and based essentially on the recent revision