An Expert System for Planning and Designing Concrete Structures for Horizontal Silos

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Introduction

- Horizontal silos are built of concrete, provide storage at considerably lower costs, and are adaptable to self feeding

- Reinforced concrete is obtained by adequately mixing in specific proportions aggregates (gravel and sand), cement, and water

- Water:cement ratio is 0.53 l/kg and cement:sand:gravel mass ratio is 1:2.2:3.7 (Lindley and Whitaker, 1996)

Introduction

Objectives

The objective is to develop a tool to:

- **design concrete horizontal silos**
- **compute the required amounts of construction materials**
- **calculate capital investment and fixed, variable, and total costs**

Methodology

- A mathematical model was developed to design horizontal silos
- An electronic spark map was developed using MS-Excel
- The mathematical model was then integrated into the spark map
- C# was used to develop a software via the spark map
- Model validation was carried out using data of 4 horizontal silos
- COV and σ were calculated

Methodology

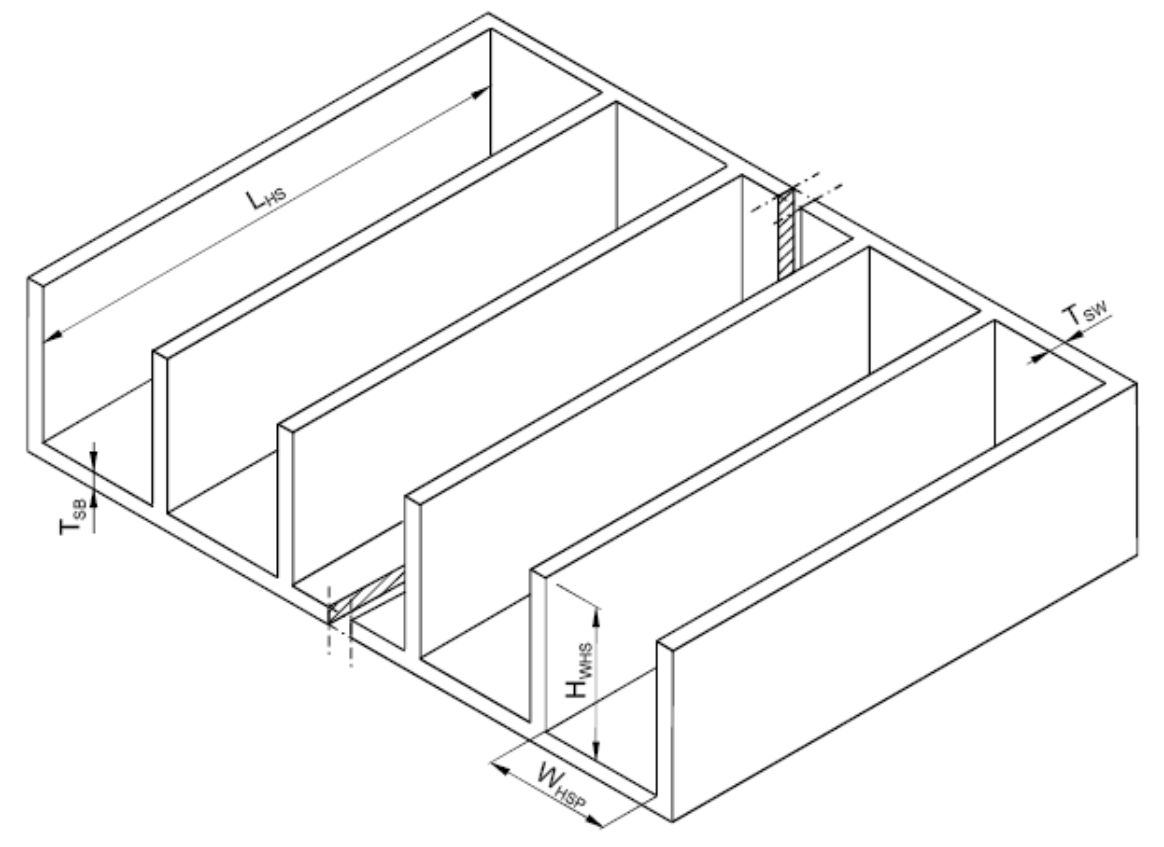


Figure 1: Concrete Horizontal Silo

Results and Discussion

Electronic Spark Map

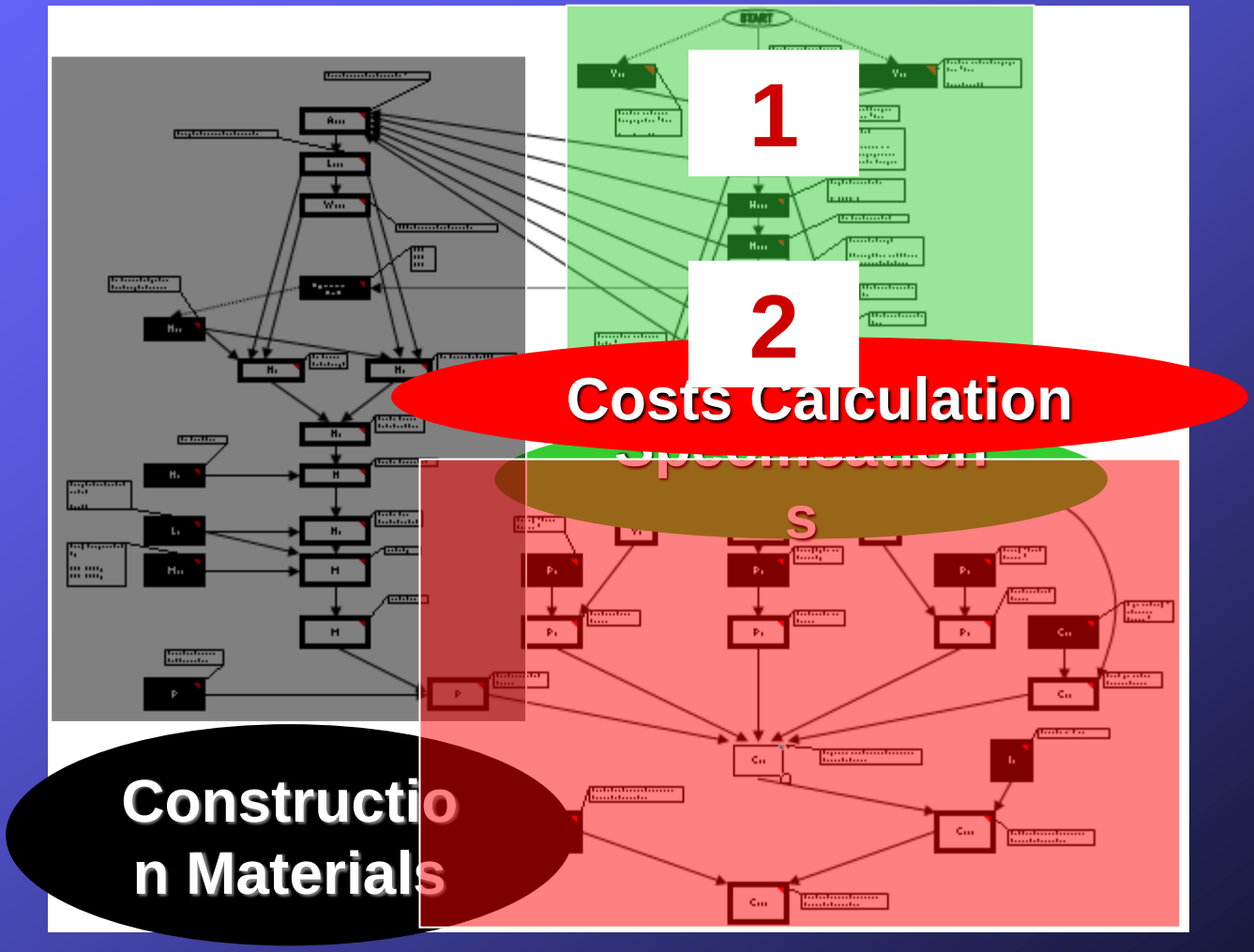
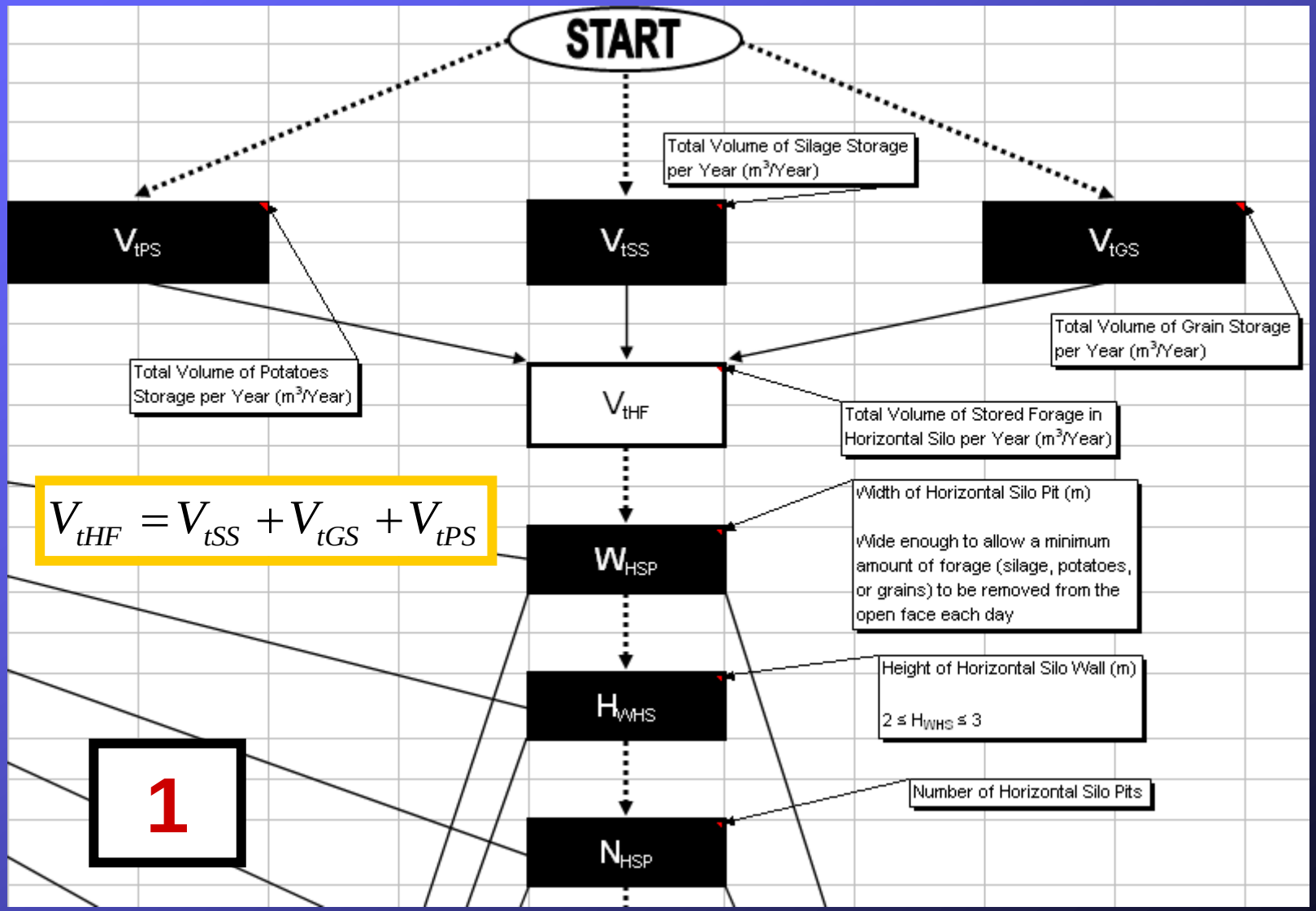


Figure 2: Electronic Spark Map

Results and Discussion

Mathematical Model



Results and Discussion

Mathematical Model

$$L_{HS} = \frac{V_{tHF}}{W_{HSP} \times H_{WHS} \times N_{HSP}}$$

L_{HS}

Horizontal Silo Length (m)

The length is determined by the total Forage needed for the year

T_{SW}

Thickness of Horizontal Silo Walls (m)

$$V_{BHS} = N_{HSP} \times L_{HS} \times W_{HSP} \times T_{SB}$$

Concrete Volume of Horizontal Silo Walls (m^3)

T_{SB}

Concrete Volume of Horizontal Silo Base (m^3)

V_{WHS}

V_{BHS}

$$V_{WHS} = \left[N_{HSP} \times W_{HSP} \times T_{SW} \times \left(H_{WHS} + T_{SB}\right)\right]$$

$$+\left[\left(N_{HSP}+1\right) \times \left(L_{HS} + T_{SW}\right) \times T_{SW} \times \left(H_{WHS} + T_{SB}\right)\right]$$

2

V_{CHS}

$$V_{CHS} = V_{BHS} + V_{WHS}$$

Results and Discussion

Electronic Spark Map

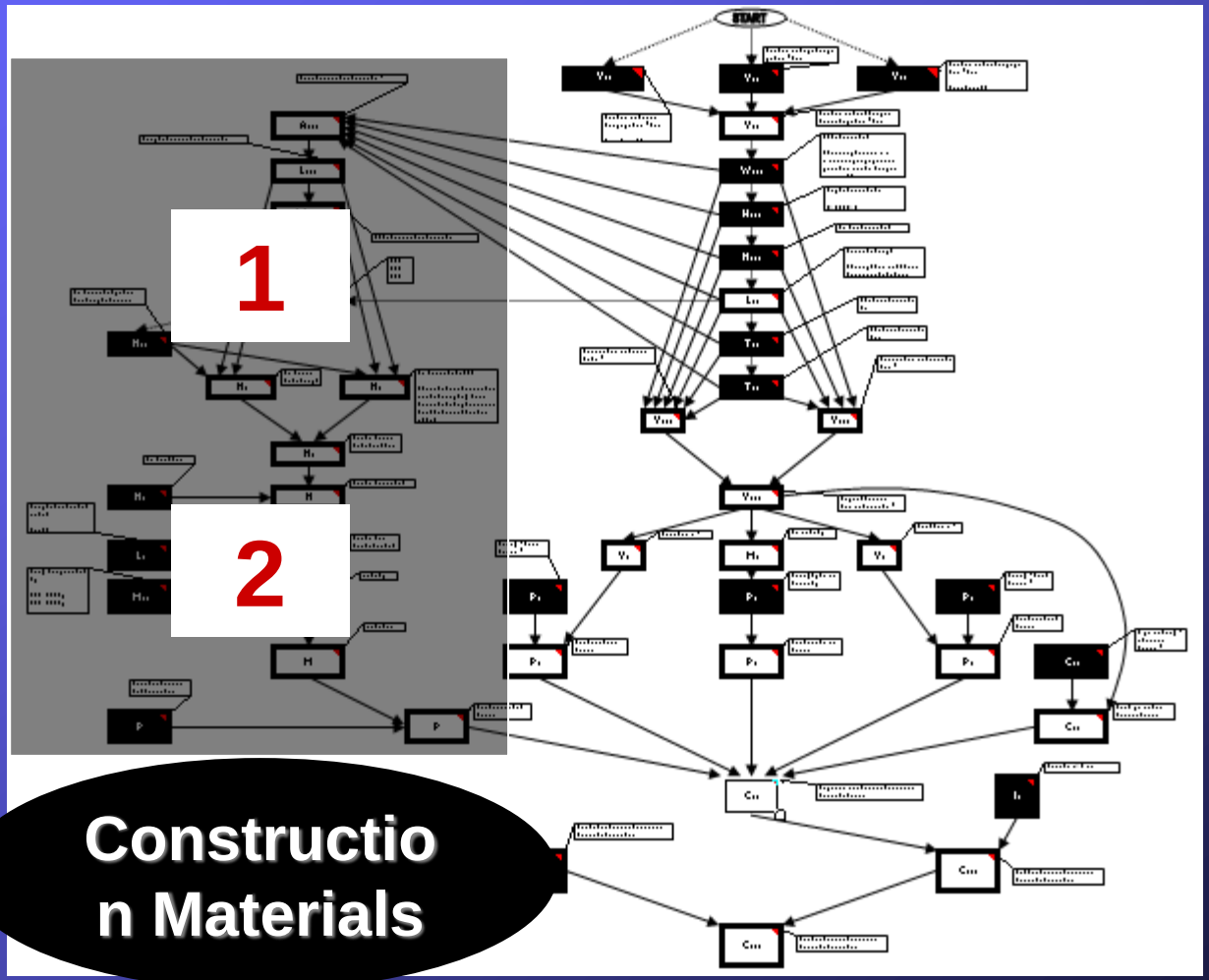


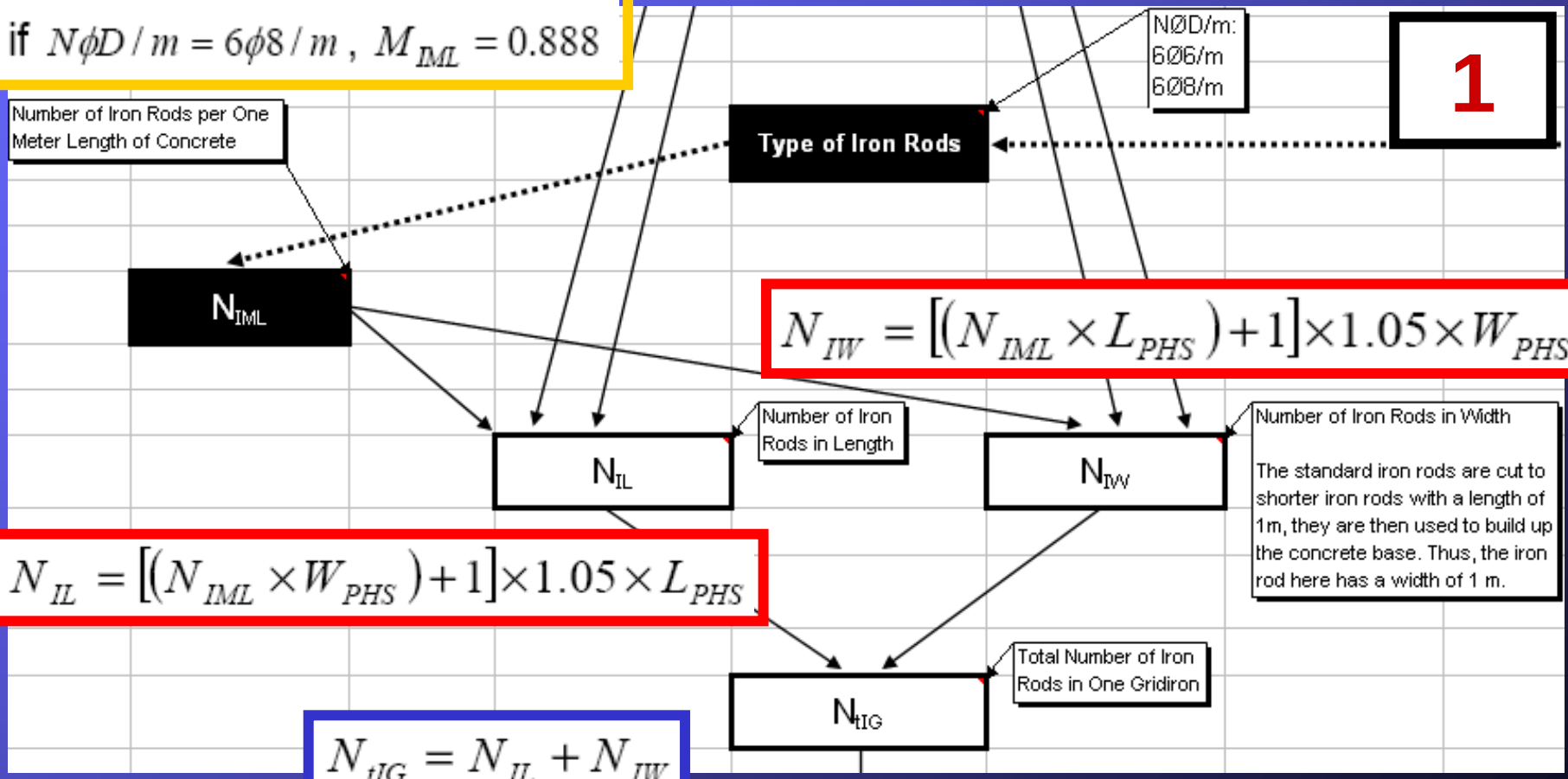
Figure 2: Electronic Spark Map

Results and Discussion

Mathematical Model

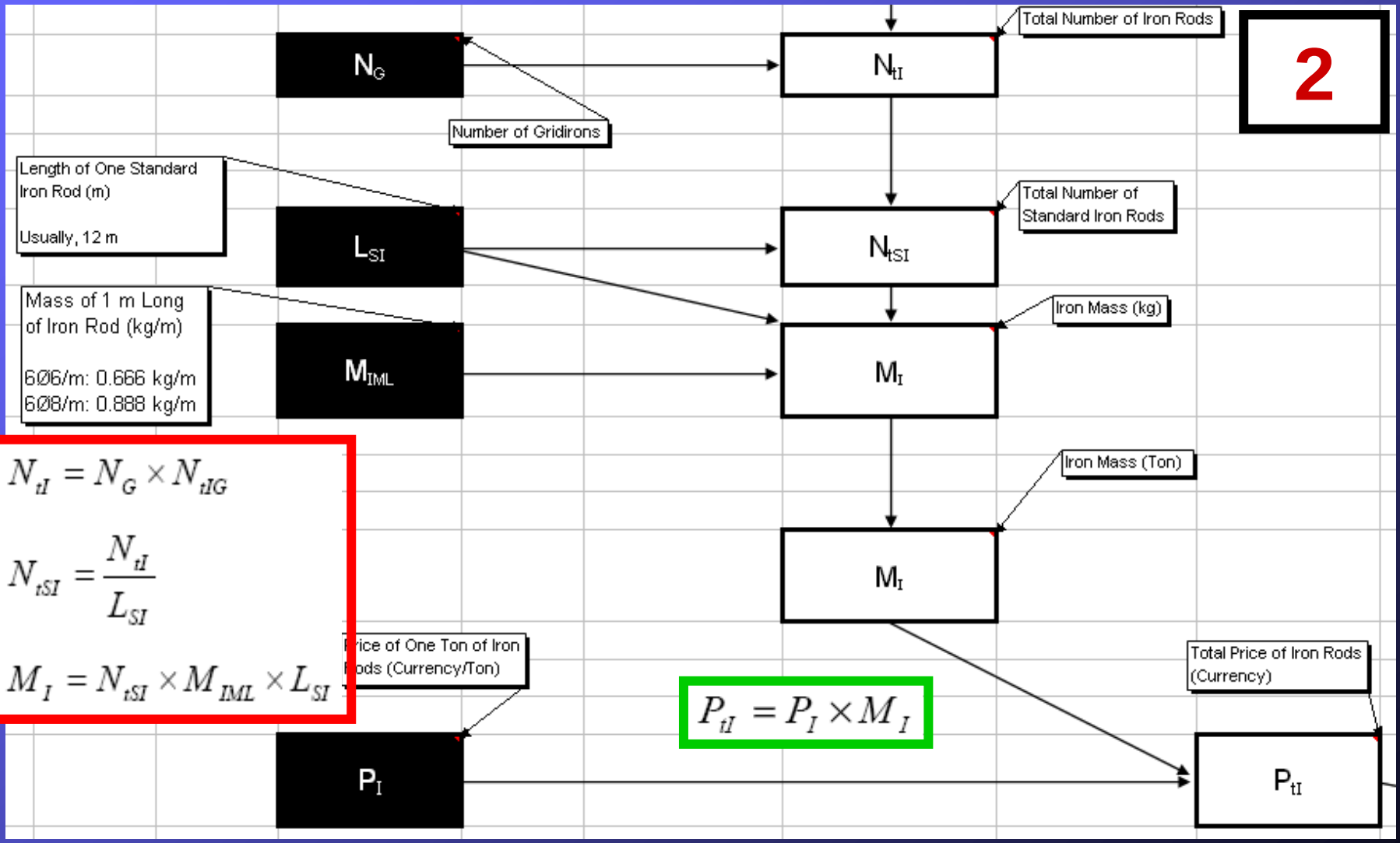
if $N\phi D/m = 6\phi 6/m$, $M_{IML} = 0.666$

if $N\phi D/m = 6\phi 8/m$, $M_{IML} = 0.888$



Results and Discussion

Mathematical Model



Results and Discussion

Electronic Spark Map

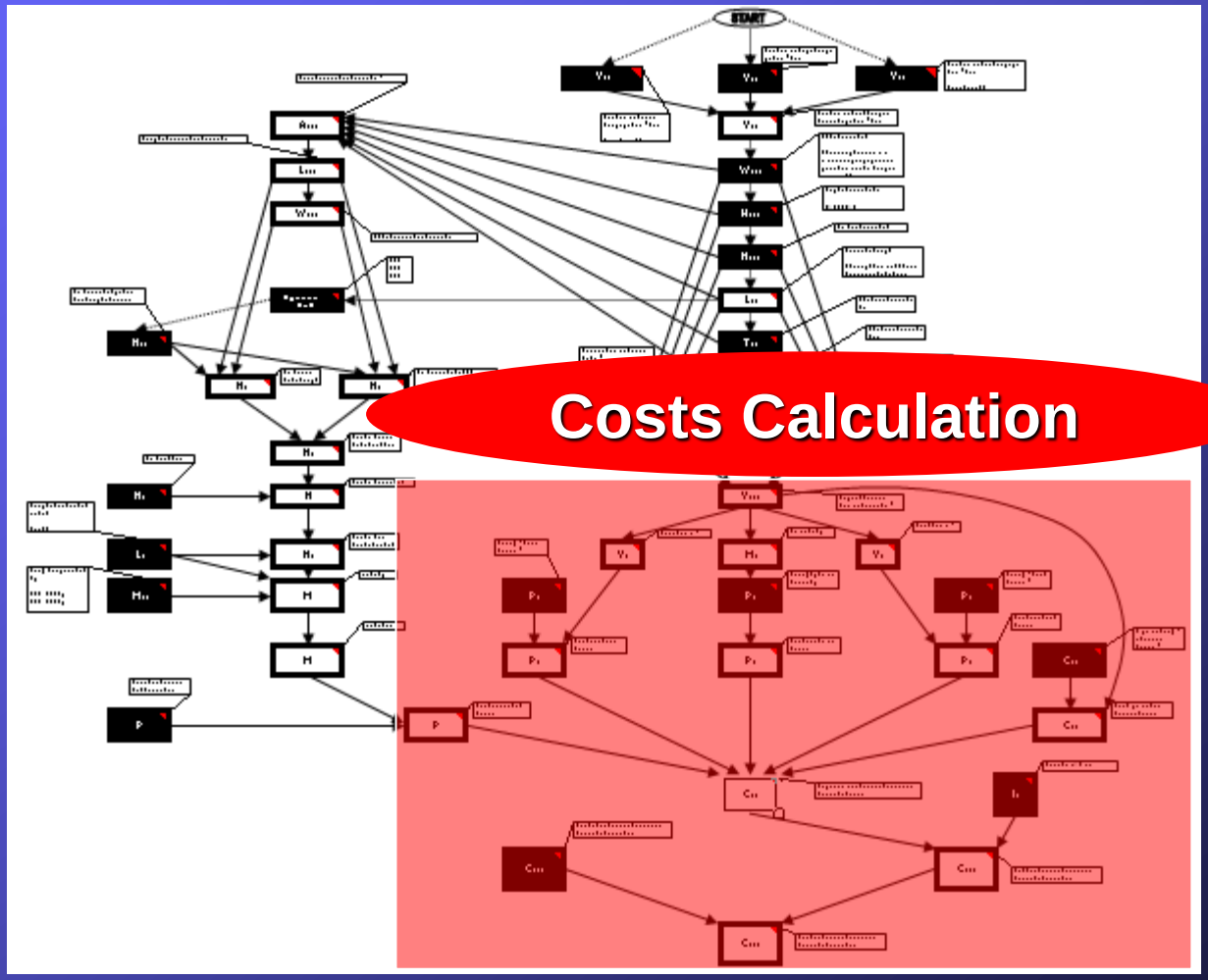
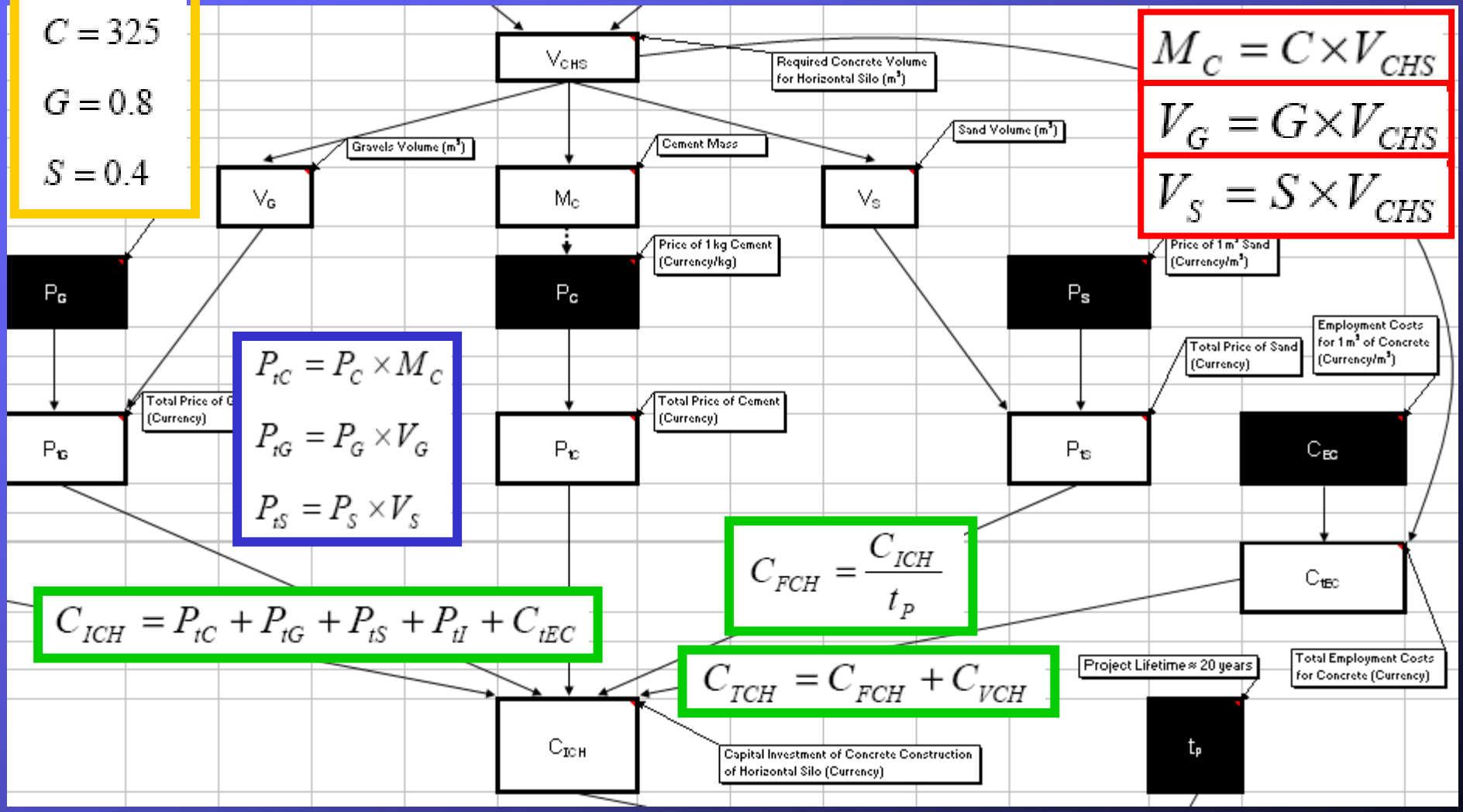


Figure 2: Electronic Spark Map

Results and Discussion

Mathematical Model



Results and Discussion

Electronic Spark Map

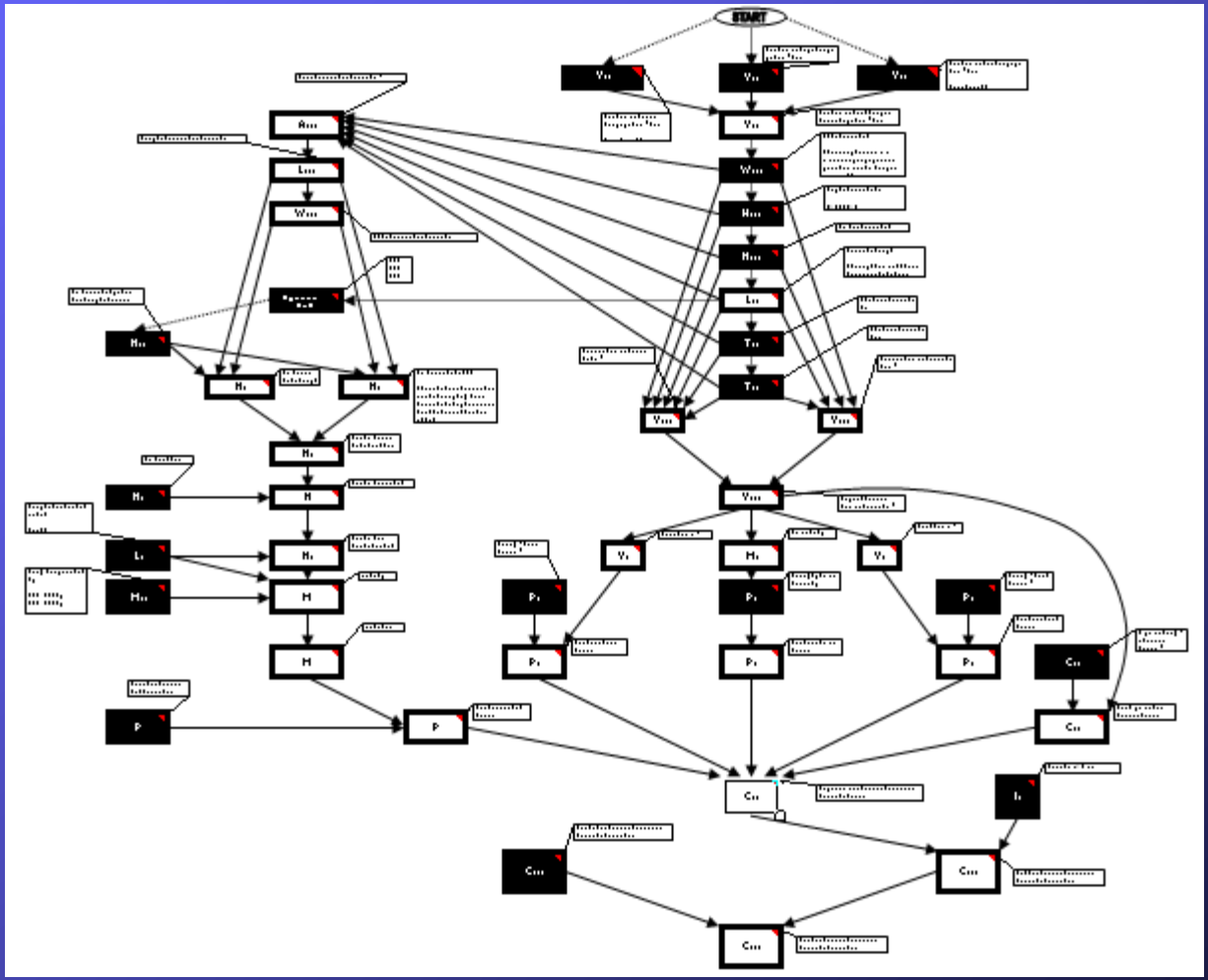


Figure 2: Electronic Spark Map

Results and Discussion

Computer Software

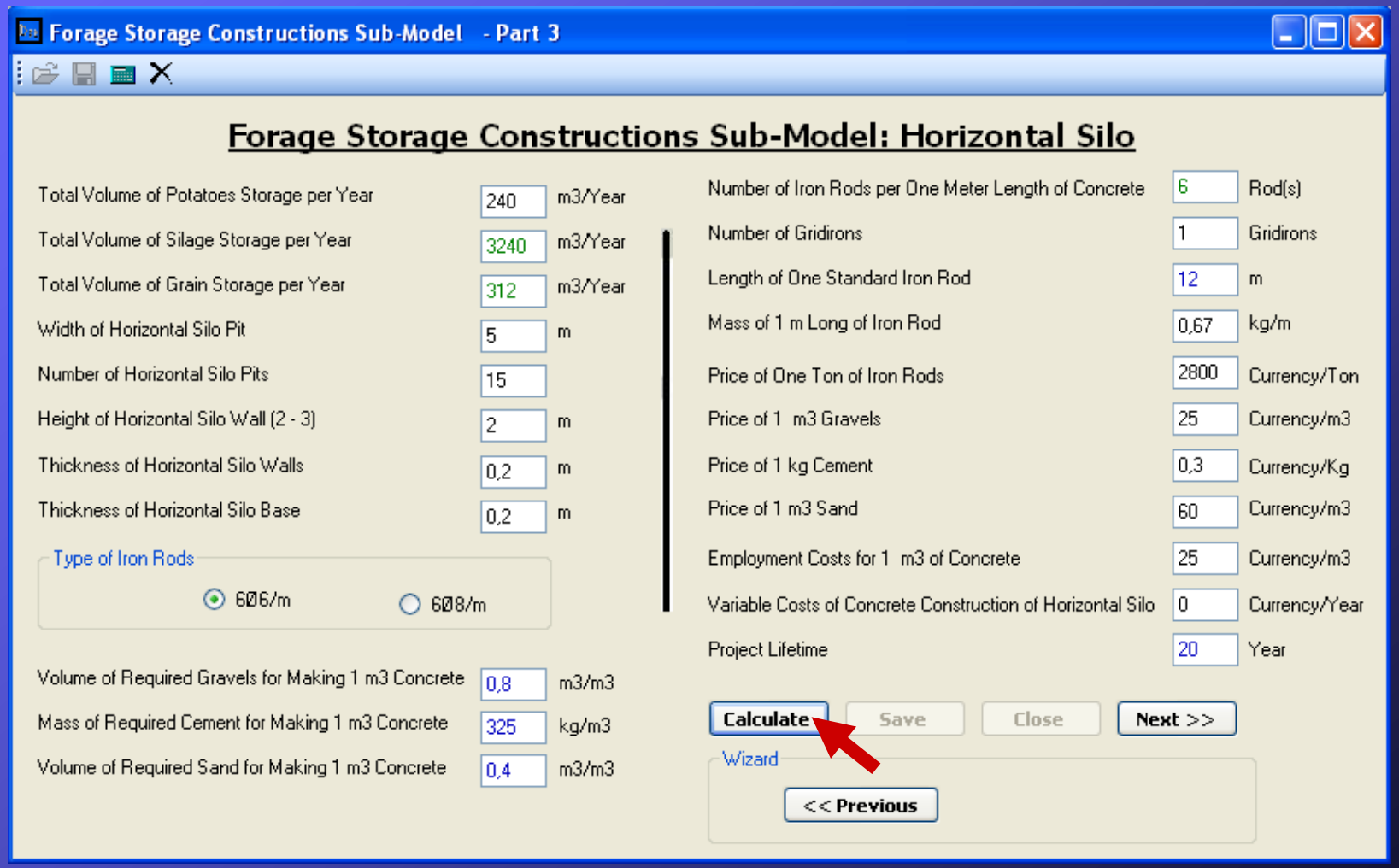


Figure 3: Input data window of horizontal silo

Results and Discussion

Computer Software

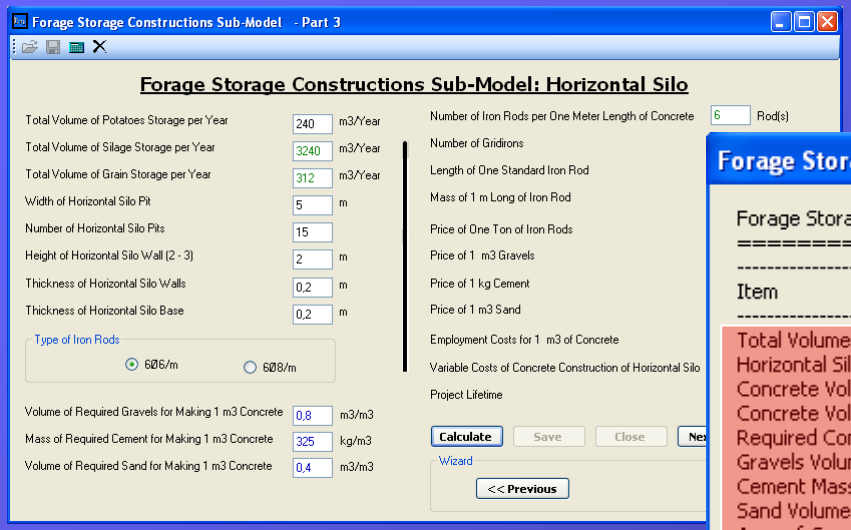


Figure 3: Input data window of horizontal silo

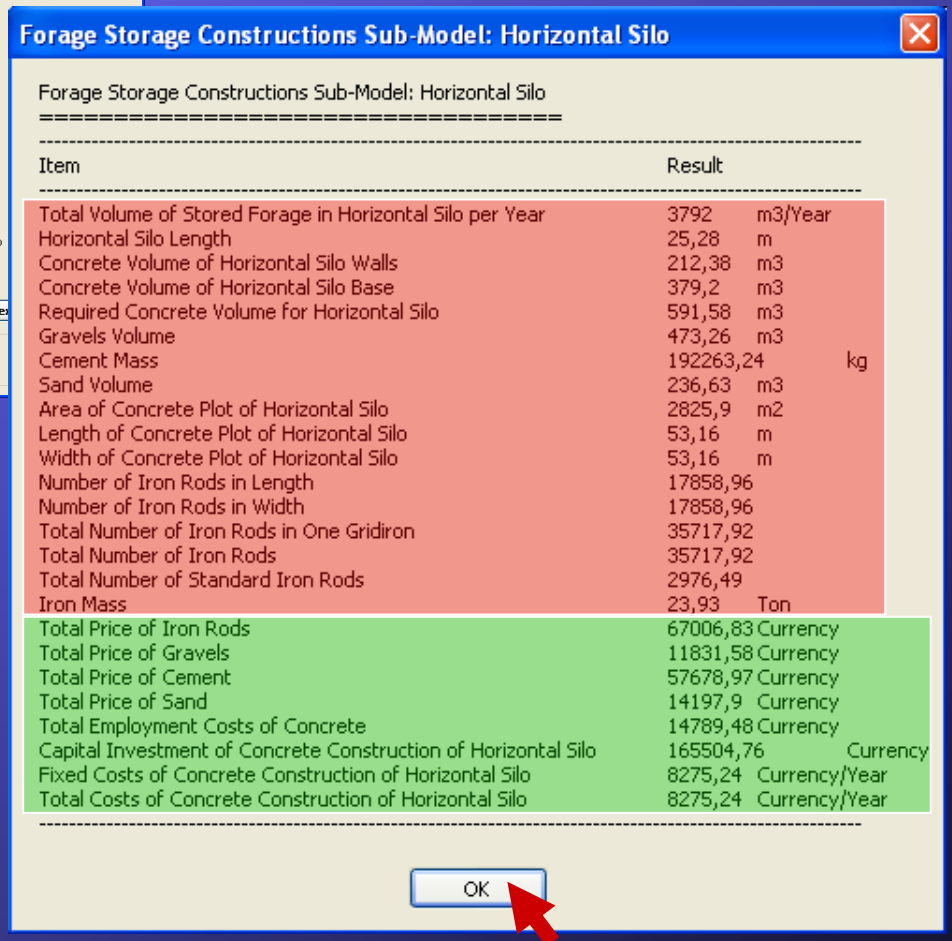


Figure 4: Output data window of horizontal silo

Results and Discussion

Validation and Evaluation

Table 1: Data of 4 concrete horizontal silos

	Parameter	V_{CHS}	V_G	M_C	V_S	M_I
Silo 1	Actual Value	600.3	479.2	193.2	240	24.17
	Calculated Value	594.2	475.4	193.1	237.7	23.92
Silo 2	Actual Value	732	585	235.8	292.5	29.49
	Calculated Value	725.2	580.1	235.7	290.1	29.21
Silo 3	Actual Value	972.5	776	313.1	389	33.35
	Calculated Value	962.9	770.3	312.9	385.2	33.04
Silo 4	Actual Value	100.9	80.6	32.5	40.4	3.82
	Calculated Value	99.9	79.9	32.5	39.9	3.78

- **COV ranges between 3.4% and 7.3%**
- **The system's accuracy is 98%**

Conclusions

- Most mathematical models can be developed as spark maps in order to simplify their use for practical implementation
- The spark map can be then instantly used to make calculations, and to get automatically the results of the input settings
- Spark map (semi-automatic system) → back diagram code of the computer software (automatic system)

Summary

- A mathematical model and a spark map were developed
- The mathematical model is then integrated into the spark map
- A computer software was developed using C# language
- Data of 4 concrete horizontal silos were used to carry out the model validation and evaluation

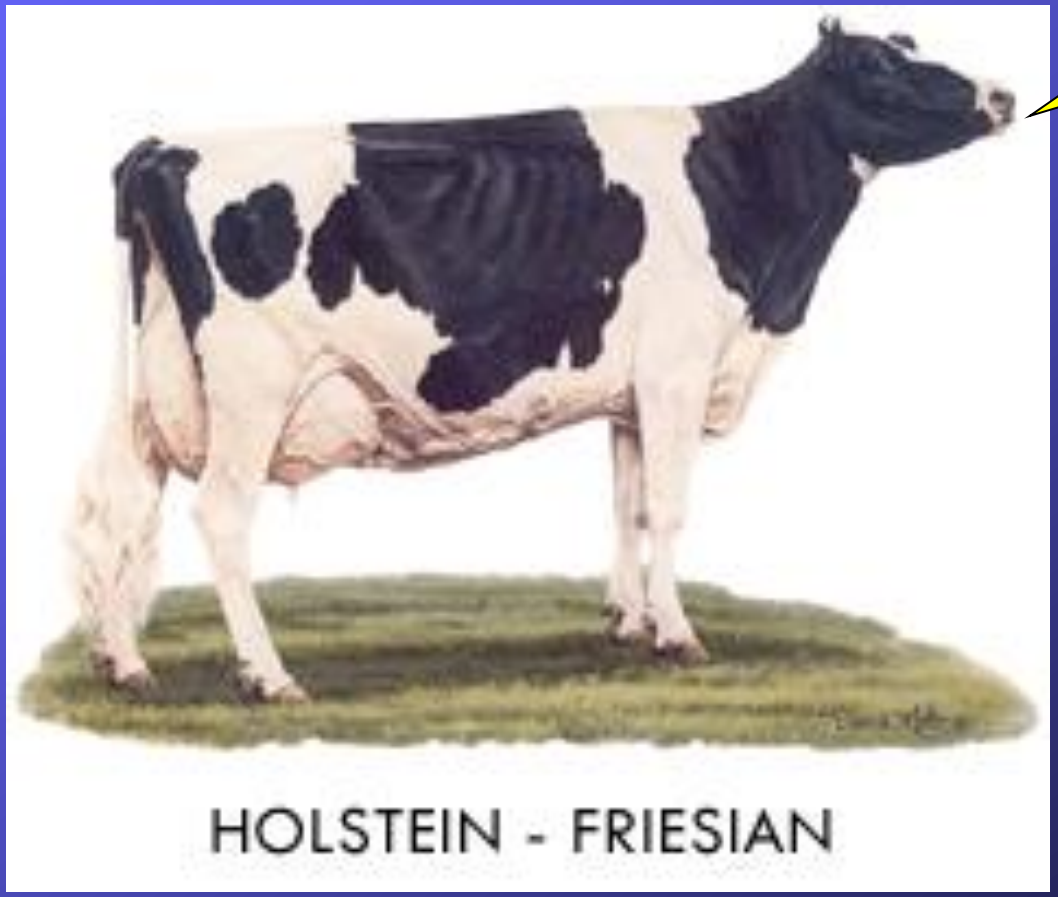
Perspective

- **The main models were developed:**
  1. Design Model
  2. Costs Calculation Model

- **Additional sub-models were developed:**
  - Concrete Base
  - Forage Storage
  - Manure Tanks
  - Farm Planning
  - Cooling System
  - Water Consumption and Sources
  - Electricity Consumption and Sources
  - Roof Materials & Structures
  - Milking Parlor Constructions
  - Biogas Plant Constructions

- **Expert System Configuration**

Thank You !



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