

# Computer modeling influence lines of farm elements

*Evgenij Kudryavtsev*

Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

**Abstract.** The article describes process of computer modeling of influence lines of each element of any section of farms with parallel belts and with diagonal elements in system Mathcad. The algorithm calculates and shows an influence lines in any chosen farm elements in any farm section with parallel belts and with diagonal elements. The proposed procedures of modeling an influence lines allow to decrease time and costs on execution of such calculations as minimum in ten times and efficiently to execute researches when farm elements parameters change.

## 1 Introduction

Computer modeling, designing and computation intended for decision of the diversified problems are receiving more and more propagation [1-20] and allows:

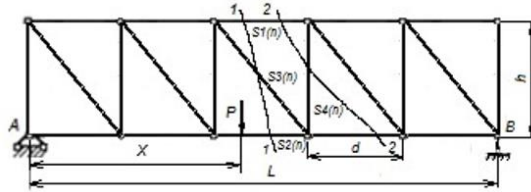
- to raise efficiency, accuracy and objectivity of received decisions;
- to raise quality and reliability of created products, processes and systems;
- to release the expert from routine and not creative activity;
- to reduce volume of researches, time and cost of workings out.

Wide use of computer modeling, designing and calculation especially at the earliest stages of creation of products, processes and systems allows to reduce huge losses at the next stages of cycles life.

The article describes process of computer modeling of influence lines of each element of any section of farms with parallel belts and with diagonal elements in system Mathcad.

Influence lines are used for calculation of many constructions which are under the influence of mobile loadings (farms of roadways; automobile and railway bridges, etc.). The question of unprofitable position of loading at which the size of settlement efforts in sections of elements of a design appears the greatest is solved with their help. Research objective - creation of algorithm and a complex of programs for automation of calculation and influence lines construction of all farm elements.

An influence line is the schedule showing change of size of effort in any farm element at movement of load unit. Process computer modeling influence lines we will be consider on an example of farm with parallel belts and diagonal elements fig. 1.



**Fig 1.** Farm with parallel belts and diagonal elements

Basic parameters of a farm are: length  $L$  and height  $h$  of a farm; number of sections in a farm  $N$ . For effort definition of each farm section element use method Rittera. Let's designate: the top horizontal element in  $n$ -th section of farm through  $S1(n)$  and effort in it through  $H1(X,n)$ ; the bottom horizontal element -  $S2(n)$  and effort -  $H2(X,n)$ ; diagonal element -  $S3(n)$  and effort -  $D(X,n)$ ; a vertical element -  $S4(n)$  and effort -  $V(X,n)$  figure 1.

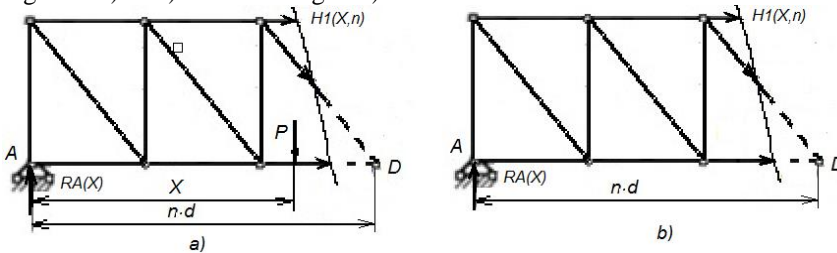
## 2 Theoretical basis

The algorithm of calculation of influence lines of each element of farm includes:

1. Definition vertical reactions  $RA(X)$  and  $RB(X)$  figure 1:

$$\begin{aligned} \sum M_A = 0; \quad RB(X) \cdot L = P \cdot X; \quad (X) = P \cdot X / L; \\ \sum M_B = 0; \quad RA(X) \cdot L = P \cdot (L - X); \quad RA(X) = P \cdot (L - X) / L = P \cdot (1 - X / L); \end{aligned} \quad (1)$$

2. Definition effort  $H1(X, n)$  in a element  $S1(n)$ . It's possible two variants: a) with load unit  $P$  figure 2 a) or b) without  $P$  fig. 2 b).



**Fig. 2.** Definition schemes of effort  $H1(X,n)$  in element  $S1(n)$  for section  $n$  with load unit  $P$  located: a) before a node  $D$ ; b) after a node  $D$

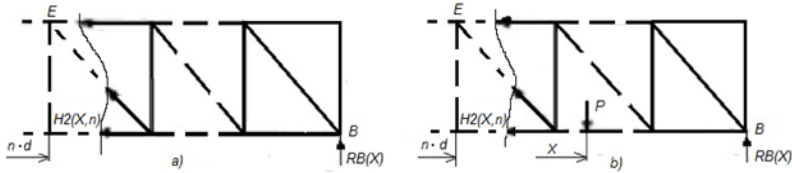
- a) load unit operates before node  $D$ ,  $X \leq n \cdot d$  fig. 2 a):

$$\begin{aligned} \sum M_D = 0; \quad H1(X,n) \cdot h - P \cdot (n \cdot d - X) + RA(X) \cdot n \cdot d = 0; \\ H1(X,n) = [P \cdot (n \cdot d - X) - RA(X) \cdot n \cdot d] / h, \end{aligned} \quad (2)$$

- b) load unit operates after node  $D$ ,  $X > n \cdot d$  fig. 2 b):

$$\begin{aligned} \sum M_D = 0; \quad H1(X,n) \cdot h + RA(X) \cdot n \cdot d = 0; \\ H1(X,n) = -RA(X) \cdot n \cdot d / h, \end{aligned} \quad (3)$$

3. Definition of effort  $H2(X, n)$  in element  $S2(n)$ . It's possible two variants: a) without load unit  $P$  fig. 3 a) or b) with  $P$  fig. 3 b).



**Fig. 3.** Definition schemes of effort  $H2(X,n)$  in element  $S2(n)$  for sections  $n$  with load unit  $P$  located: a) before; b) after farm node  $E$

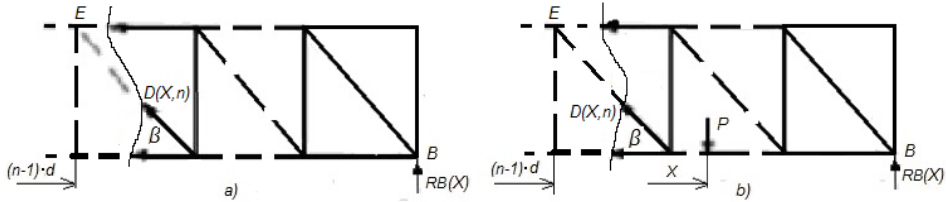
a) load unit operates before node  $E$  fig. 3 a) ( $X \leq (n-1) \cdot d$ ):

$$\sum M_E = 0; \quad H2(X,n) \cdot h - RB(X) \cdot (L - n \cdot d) = 0; \\ H2(X,n) = RB(X) \cdot (L - n \cdot d) / h; \quad (4)$$

b) load unit operates after node  $E$  fig. 3 b) ( $X > n \cdot d$ ):

$$\sum M_E = 0; \quad H2(X,n) \cdot h + P \cdot (X - n \cdot d) - RB(X) \cdot (L - n \cdot d) = 0; \\ H2(X,n) = [RB(X) \cdot (L - n \cdot d) - P \cdot (X - n \cdot d)] / h. \quad (5)$$

4. Definition of effort  $D(X,n)$  in element  $S3(n)$ . It's possible two variants: a) without load unit  $P$  figure 4 a) or b) with  $P$  fig. 4 b).



**Fig. 4.** Definition schemes of effort  $D(X,n)$  in element  $S3(n)$  for sections  $n$  with load unit  $P$  located: a) before; b) after farm node  $E$

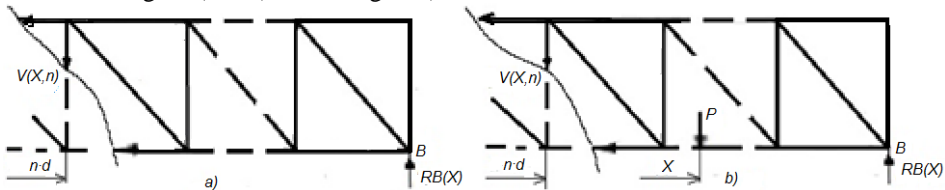
a) load unit operates before node  $E$  fig. 4 a) ( $X \leq (n-1) \cdot d$ ):

$$\sum Y = 0; \quad D(X,n) \cdot \sin(\beta) + RB(X) = 0; \quad D(X,n) = -RB(X) / \sin(\beta); \quad (6)$$

b) load unit operates after element  $S3(n)$  ( $X > (n-1) \cdot d$ ) fig. 4 b):

$$\sum Y = 0; \quad D(X,n) \cdot \sin(\beta) + RB(X) - P = 0; \quad D(X,n) = (P - RB(X)) / \sin(\beta); \quad (7)$$

5. Definition of effort  $V(X,n)$  in element  $S4(n)$ . It's possible two variants: a) without load unit  $P$  fig. 5 a) or b) with  $P$  fig. 5 b).



**Fig. 5.** Definition schemes of effort  $V(X,n)$  in element  $S4(n)$  for sections  $n$  with load unit  $P$  located: a) before; b) after element  $S4(n)$

a) load unit operates before element  $S4(n)$  ( $X \leq n \cdot d$ ) fig. 5 a):

$$\sum Y = 0; \quad V(X, n) - RB(X) = 0; \quad V(X, n) = RB(X); \quad (8)$$

b) load unit operates after element  $S4(n)$  ( $X > n \cdot d$ ) fig. 5 b):

$$\sum Y = 0; \quad V(X, n) - RB(X) + P = 0; \quad V(X, n) = RB(X) - P; \quad (9)$$

### 3 Computer modeling

Modeling influence lines of farms elements with parallel belts and diagonal elements descending in system Mathcad

Input data:

- length and height of beam truss, m  $L:=32.0 \quad h:=6.2$
- number of panels  $N:=8$
- load unit  $P:=1$

Calculation algorithm:

1. Analytic forms the influence lines  $RA(X)$  and  $RB(X)$  the vertical reactions at supports:

$$NC := \frac{N}{2} \quad d := \frac{L}{N} \quad RB(X) := P \cdot \frac{X}{L} \quad RA(X) := P \cdot \left(1 - \frac{X}{L}\right) \quad \sin \beta := \frac{h}{\sqrt{h^2 + d^2}}, \quad (10)$$

2. Calculation program for influence lines  $HI(n)$  in element  $S1(n)$  fig. 6.

$$HI(n) := \begin{cases} \text{for } i \in 0..N \\ X_i \leftarrow i \cdot d \\ Y_i \leftarrow \frac{P \cdot (n \cdot d - X_i) - RA(X_i) \cdot n \cdot d}{h} \quad \text{if } X_i \leq (n-1) \cdot d \\ Y_i \leftarrow \frac{-RA(X_i) \cdot n \cdot d}{h} \quad \text{otherwise} \end{cases}$$

**Fig. 6.** Calculation program for influence line  $HI(n)$  in element  $S1(n)$

3. Calculation program for influence lines  $H2(n)$  in element  $S2(n)$  fig. 7

$$H2(n) := \begin{cases} \text{for } i \in 0..N \\ X_i \leftarrow i \cdot d \\ Y_i \leftarrow \frac{RB(X_i) \cdot (L - n \cdot d)}{h} \quad \text{if } X_i \leq n \cdot d \\ Y_i \leftarrow \frac{RB(X_i) \cdot (L - n \cdot d) - P \cdot (X_i - n \cdot d)}{h} \quad \text{otherwise} \end{cases}$$

**Fig. 7.** Calculation program for influence line  $H2(n)$  in element  $S2(n)$

4. Calculation program for influence lines  $D(n)$  in element  $S3(n)$  fig. 8.

$$D(n) := \begin{cases} \text{for } i \in 0..N \\ X_i \leftarrow i \cdot d \\ Y_i \leftarrow \frac{-RB(X_i)}{\sin \beta} \quad \text{if } X_i \leq (n-1) \cdot d \\ Y_i \leftarrow \frac{P - RB(X_i)}{\sin \beta} \quad \text{otherwise} \end{cases}$$

**Fig. 8.** Calculation program for influence line  $D(n)$  in element  $S3(n)$

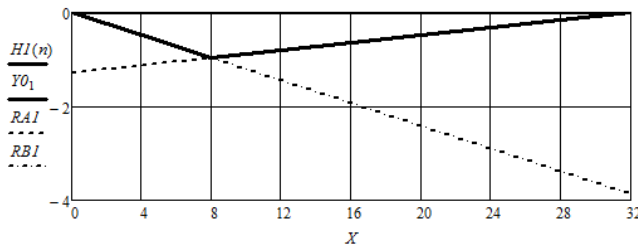
5. Calculation program for influence lines  $V(n)$  in element  $S4(n)$  fig. 9.

$$\begin{array}{l}
 \underline{\underline{V(n)}} := \left[ \begin{array}{l} \text{for } i \in 0..N \\ \left| \begin{array}{l} X_i \leftarrow i \cdot d \\ Y_i \leftarrow RB(X_i) \text{ if } X_i \leq n \cdot d \\ Y_i \leftarrow RB(X_i) - P \text{ otherwise} \end{array} \right. \\ Y \end{array} \right. \\
 \underline{\underline{Y0}} := \left[ \begin{array}{l} \text{for } i \in 0..N \\ \left| \begin{array}{l} X_i \leftarrow i \cdot d \\ Y_i \leftarrow 0 \end{array} \right. \\ \left( \begin{array}{l} X \\ Y \end{array} \right) \end{array} \right. \quad X := Y0_0
 \end{array}$$

**Fig. 9.** Calculation program for influence line  $V(n)$  in element  $S4(n)$

6. Influence lines in each element of farm and for vertical reactions at supports  
 - influence lines  $HI(n)$  for element  $SI(n)$  and vertical reactions at supports fig. 10:

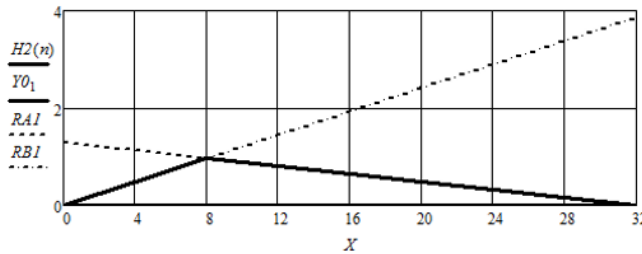
$$\begin{array}{l}
 n := 2 \quad RA1 := \frac{-n \cdot d}{h} \cdot RA(X) \quad RB1 := \frac{-(L - n \cdot d)}{h} \cdot RB(X) \\
 \max(HI(n)) = 0 \quad \min(HI(n)) = -0.968
 \end{array} \quad (11)$$



**Fig. 10.** Influence line  $HI(n)$  in element  $SI(n)$  and vertical reactions at supports

- influence lines  $H2(n)$  in element  $S2(n)$  and vertical reactions at supports fig. 11:

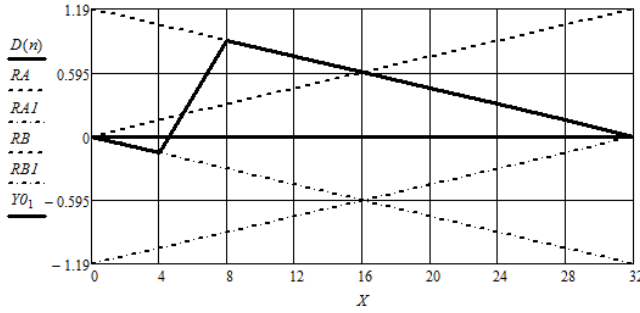
$$\begin{array}{l}
 RA1 := \frac{n \cdot d}{h} \cdot RA(X) \quad RB1 := \frac{L - n \cdot d}{h} \cdot RB(X) \quad \max(H2(n)) = 0.968 \\
 \min(H2(n)) = 0
 \end{array} \quad (12)$$



**Fig. 11.** Influence line  $H2(n)$  in element  $S3(n)$  and vertical reactions at supports

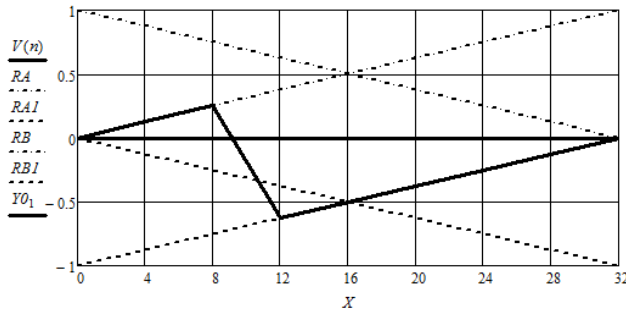
- influence lines  $D(n)$  for element  $S3(n)$  and vertical reactions at supports fig. 12:

$$\begin{array}{l}
 RA := \frac{RA(X)}{\sin \beta} \quad RB := \frac{RB(X)}{\sin \beta} \quad R := \text{round}\left(\frac{P}{\sin \beta}, 2\right) = 1.19 \\
 RA1 := RA - R \quad RB1 := RB - R \quad \max(D(n)) = 0.893 \quad \min(D(n)) = -0.149
 \end{array} \quad (13)$$



**Fig. 12.** Influence line  $D(n)$  in element  $S3(n)$  and vertical reactions at supports - influence lines  $V(n)$  for element  $S4(n)$  and of reactions at supports fig. 13:

$$\begin{aligned}
 RB &:= P \cdot \frac{X}{L} & RA &:= P \cdot \left(1 - \frac{X}{L}\right) & RB1 &:= RB - 1 & RAI &:= RA - 1 \\
 \max(V(n)) &= 0.25 & \min(V(n)) &= -0.625
 \end{aligned}
 \tag{14}$$



**Fig. 13.** Influence line  $V(n)$  in element  $S4(n)$  and vertical reactions at supports

## 4 Conclusion

Basic results of researches scientific. Are created:

1. analytical expressions of forces in any farm elements depending on position load unit;
2. algorithm and a complex of programs for automation of calculation and influence lines representation on all farm elements in system Mathcad.

The proposed procedures of modeling influence lines allows to decrease time and labour costs for execution of such calculations as minimum in many times and efficiently to guide researches related to changing parameters in any farm elements.

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