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FORCES TRANSMISSION IN THE 0/3/3 STRUCTURAL GROUP

BY

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Abstract. The paper presents an analysis of the 0/3/3 (6R) structural group, based on forces transmission quality. The authors adopt the configuration determinant as criterion of quality transmission of forces. It comes to conclusion that this group has three deviation angles of configuration, which have to limit to a admissible value. It contains the main ideas, original contributions and conclusions of the authors' research.

Key words: forces transmission, structural group, configuration determinant, transmissivity index, deviation angle.

1. Introduction

The researches dealing with problem of force transmission quality in mechanisms agree to this problem can by satisfactory solved only in case of sample mechanisms (simple four bar linkage and slider-crank mechanism) (Balli et *al*., 2002; Chen *et al*., 2002; Erman *et al*., 1997; Jensen, 1991). We consider the mode to solve this problem concerning to complex mechanisms, considering these mechanisms as being composed by structural groups. Thus, it can identify the parameters determining the quality of force transmission (transmission indices) and it can recommend the domains inside which, its variation is admissible. Certainly, the success of this approach is conditioned by

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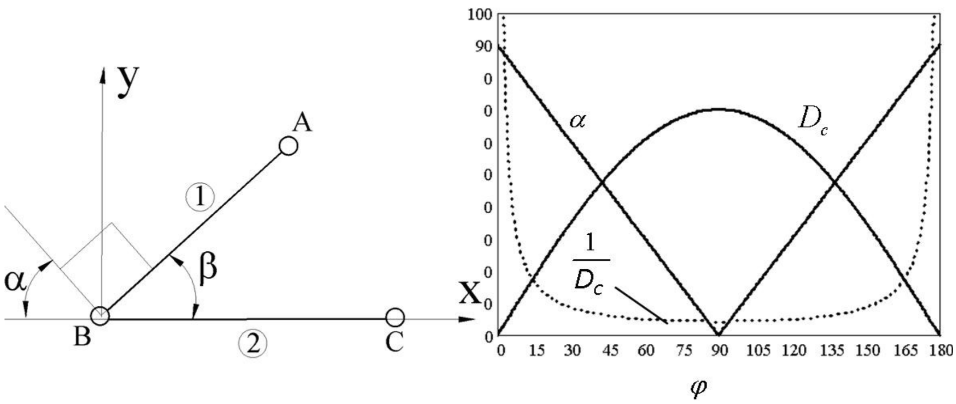
knowing transmissivity indices for usual structural groups. In a series of previous papers we analyzed the 0/2/2 structural groups, thus we consider its problem being solved (Duca, 1996; Duca *et al*., 2002; Duca & Buium, 2010).

In this paper we analyze the group 0/3/3 (6R) taking into account, the determinant intervening in kinematics and static analysis, as criterion of force transmission quality appreciation. This determinant characterize the group configuration, therefore we named it configuration determinant (D_c). It is known that value $D_c = 0$ associates with critical configuration of the group and extreme values of D_c associates with optimal configurations, according to force transmission quality. Certainly as a configuration is farther from the critical configuration and nearer from the optimal one, as the group has a favorable running. Knowing the two configurations aided by determinant D_c, allows adopting a convenient transmissivity index, easy to apply in analysis and synthesis. Starting up from this idea we will adopt transmissivity indices for the 0/3/3 (6R) structural group.

2. Analysis of the 0/3/3 (6R) Structural Group

Before to approach the 0/3/3 structural group we will present the usual structural groups 0/2/2, in order to underline the correspondence between the D_c determinant variation and transmissivity index variation.



a *b*

Fig. 1 – The case of RRR structural group: *a* – RRR structural group; *b* – variation of characteristic parameters.

In the case of 0/2/2 structural group (Fig. 1 *a*), the configuration determinant has the following expression:

$$D_c = \begin{vmatrix} (y_B - y_A) & -(y_B - y_C) \\ -(x_B - x_A) & (x_B - x_C) \end{vmatrix} = l_1 l_2 \sin\varphi . \tag{1}$$

where φ is the one position parameter. Transmissivity index is the deviation angle α. From the diagrams shown in Fig. 1 *b* it see that at $\varphi \in \{0, 180^0\}$, $D_c = 0$ and $\alpha = 90^0$ (links 1 and 2 are collinear), and for $\varphi = 90^0$, D_c has maximum value and $\alpha = 0$ (links 1 and 2 are perpendicular).

A similar situation we meet at RTT structural group (Fig. 2). There configuration determinant has expression:

$$D_c = \begin{vmatrix} (y_B - y_A) & -1 \\ -(x_B - x_A) & 0 \end{vmatrix} = l_1 \cos\varphi . \tag{2}$$

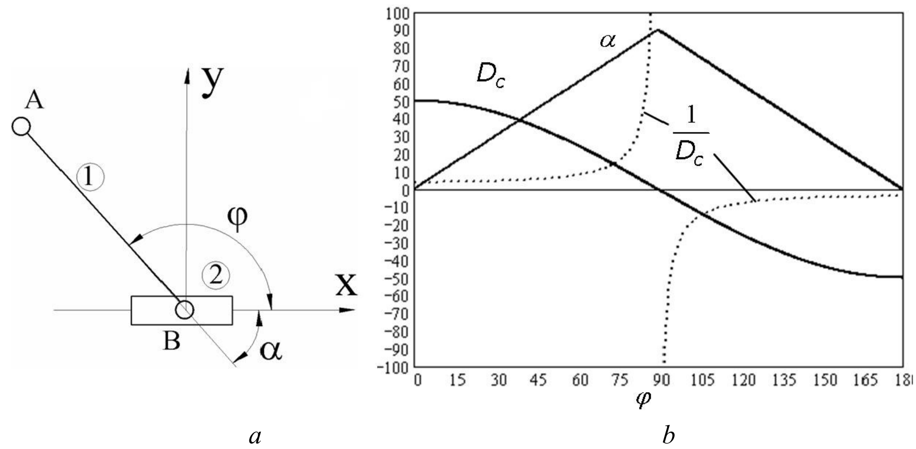
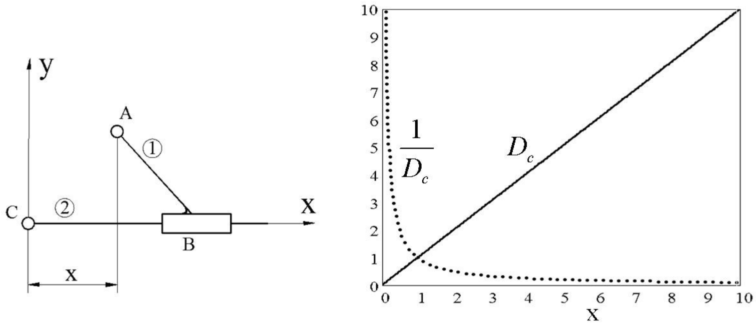


Fig. 2 – The case of RTT structural group
a – RRR structural group; *b* – variation of characteristic parameters.

The critical position is obtained at $\varphi = 90^0$ ($D_c = 0$, $\alpha = 90^0$) when link *AB* is perpendicular on translation axis and the optimum position appears at $\varphi \in \{0, 180^0\}$ (D_c − extreme, $\alpha = 0$) when *AB* is collinear with translation axis. An interesting situation intervenes at RTR structural group (Fig. 3). In this case the configuration determinant is

$$D_c = \begin{vmatrix} (y_B - y_A) & 1 \\ -(x_B - x_A) & 0 \end{vmatrix} = x , \tag{3}$$

and the transmissivity index is x. The critical configuration appears at $D_c = x = 0$, and optimal configuration appears when $D_c = x$ is the transmissivity index which tends to infinity.

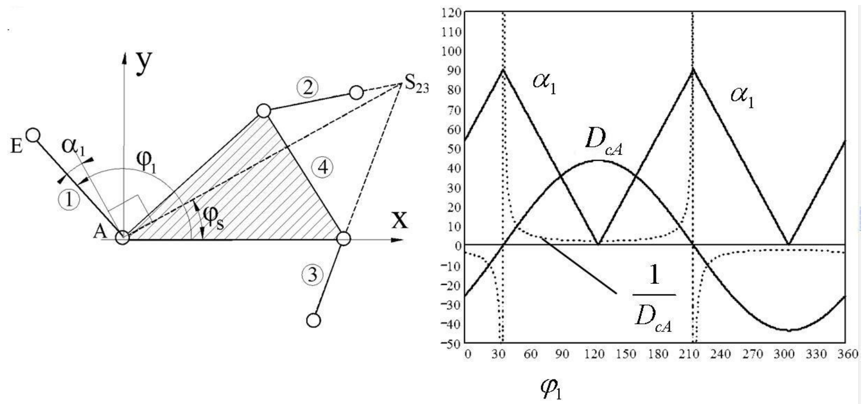


a *b*

Fig. 3 – The case of RTR structural group
a – RTR structural group; *b* – variation of characteristic parameters.

In the case of 0/3/3(6R) structural group, the configuration depends on three independent parameters $\varphi_1, \varphi_2, \varphi_3$ (Fig. 4 *a*). We apply the singular points method (Duca *et al.*, 2003), in order to find the point A velocity, taking into account the point S_{23} located at intersection of links 2 and 3. The configuration determinant D_{cA}, similar to those of the group RRR, is expressed as:

$$D_c = \begin{vmatrix} (y_A - y_E) & -(y_A - y_{S_{23}}) \\ -(x_A - x_E) & (x_A - x_{S_{23}}) \end{vmatrix} = l_1 l_{AS_{23}} \sin(\varphi_1 - \varphi_S) . \tag{4}$$



a *b*

Fig. 4 – The case of 0/3/3 (6R) structural group
a – 0/3/3 (6R) structural group; *b* – variation of characteristic parameters.

The $D_{cA}(\varphi_1)$ variation (Fig. 4*b*) allows to specify the critical and optimal configurations under the circumstances that φ_2 and φ_3 are given and φ_1 is variable. Thus, the critical configurations appear at $\varphi_1 = \varphi_S$ and $\varphi_1 = \pi + \varphi_S$ and optimal configurations appear at $\varphi_1 = \varphi_S + \frac{\pi}{2}$ and $\varphi_1 = \frac{3\pi}{2} + \varphi_S$. Under these circumstances we can adopt the transmissivity index $\alpha_1 -$ the sharp angle between AE and the perpendicular on AS_{23} from point A. This angle has the same properties as deviation angle from the RRR structural group. Similarly to α_1 it can define the φ_2 and φ_3 angles. Consequently, this group has three deviation angles α_1, α_2, α_3 (Fig. 5) which have to respect conditions

$$\alpha_1 \le \alpha_a, \ \ \alpha_2 \le \alpha_a, \ \ \alpha_3 \le \alpha_a, \tag{5}$$

or

$$\max(\alpha_1, \alpha_2, \alpha_3) \le \alpha_a \tag{6}$$

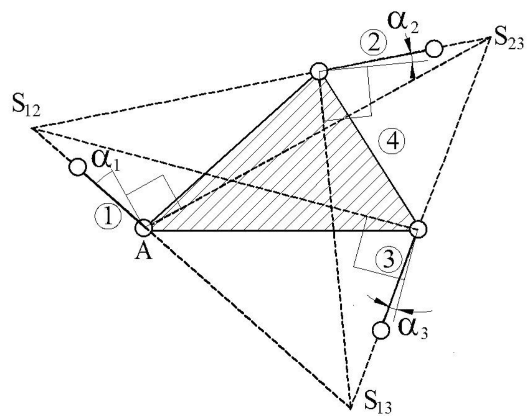


Fig. 5 – Tranmissivity indices of the 0/3/3 (6R) structural group.

4. Conclusions

1. Taking the configuration determinant as criterion to evaluate the force transmission quality, we established that 0/3/3 (6R) structural group has three transmissivity indices. We adopted in this way three deviation angles which have to limit at an admissible value.

2. In order the study to be continued, is useful to find out an optimal global configuration, as a nonlinear programming problem, considering the objective function:

$$\max(\alpha_1, \alpha_2, \alpha_3)_{\varphi_1, \varphi_2, \varphi_3} \rightarrow \min \quad (7)$$

Interesting to research is also that are a configuration for which all three deviation angles equal zero ($\alpha_1 = \alpha_2 = \alpha_3 = 0$).

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TRANSMITEREA FORŢELOR ÎN CAZUL GRUPEI STRUCTURALE 0/3/3

(Rezumat)

Lucrarea prezintă o analiză a grupei structurale 0/3/3 (6R) din punctul de vedere al calităţii transmiterii forţelor. Autorii adoptă drept criteriu de apreciere al acestei calităţi, determinantul de configuraţie. Se ajunge la concluzia că această grupă are trei unghiuri de deviaţie care trebuie limitate la o valoare admisibilă.