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Mathematical Modeling of Experimental Search Outcomes of Asphalt-Concrete

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We aim to determine modification of physical mechanical characteristics of modified bitumen and asphalt-concrete according to modification of number of different bitumen modifier.

Each experiment is normally very labor-consuming and connected to some expenditure. That's why it is expedient to build such mathematical models which will give us an opportunity to forecast experiment outcomes and only after it make physical experiment. It gives a chance to decrease significantly number of physical experiments.

We have done series of experiments resulted in the following dataTable N1

N	Data obtained as a result of experiment			
	X_1	X_2	X_3	f
1	0	102	45	1.35
2	2	75	50	1.77
3	3	71	53	2.36
4	4	59	58	2.53

Table N1. Data obtained as a result of experiment, where X1 is percentage composition of polymer in bitumen;X2 – penetration; X3- softening temperature of bitumenandf–solidity of asphalt-concrete at compression at 50^0C

In order to solve the problem of forecast of experiment outcomes, we used simple mathematical apparatus, namely:

I. Polynomial interpolation,

II. Least-squares method

As we know, X_2(penetration), X_3 (softening temperature of bitumen) and f(solidity of asphalt-concrete at compression at 50^0C) are depended on X_1(percentage composition of polymer in

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bitumen). This admission is conditional, becausef is depended on all three variables. But firstly we consider the simplest occasion, when:$x_2 = f_2(x_1)$;$x_3 = f_3(x_1)$; $f = f(x_1)$.

I.e.,we are researching dependenceofx_2, $x_3$and$f$on x_1. It's true thatwe do not know images off_2, f_3და f. Methods which we are discussing in dissertation thesis give an opportunity to build such functions, which will be "close" with the functions we are interested in.

I. Through polynomial interpolation, we will build such function, meanings of which will coincide with meanings of searching function, namely thosemeanings ofx_1, which were taken at the time of experiment. We will usepolynomial interpolation of first and second row. Computer packet „Mathematica 8" was used for calculations and such meanings of searching quantities were calculated, for which we had not made physical experiment.Outcomes of calculations are given in Tables N2 and N3.

	Calculated (by second row polynomial interpolation)			
N	X_1	X_2	X_3	f
1	1	85.3333	47.3333	1.43333
2	1.2	82.76	47.84	1.4804
3	2.5	74.	51.25	2.1175
4	3.5	66.	55.25	2.4975

Table N2. Outcomes obtained by using second row polynomial interpolation

	Calculated (by first row polynomial interpolation)			
N	X_1	X_2	X_3	f
1	1	88.5	47.5	1.56
2	1.2	85.8	48.	1.602
3	2.5	73.	51.5	2.065
4	3.5	65.	55.5	2.445

Table N3. Outcomes obtained by using first row polynomial interpolation

Afterwards, in order to estimate accuracy of results obtained by mathematical model, we have made physical experiment for the case whenX_1 (percentage composition of polymer in bitumen)=2.5. As a result of physical experiment, we have obtained the following results$x_2 = 73.7$; $x_3 = 51{,}8$and$f = 2.075$,which is well agreed with the results obtained by mathematical model.

It affirms our opinion regarding the fact that the mathematical model may be used for forecasting the experiment outcomes. It is true that accuracy of mathematical model will be increased more if we have more number of experiment data;as well, if we use multivariate

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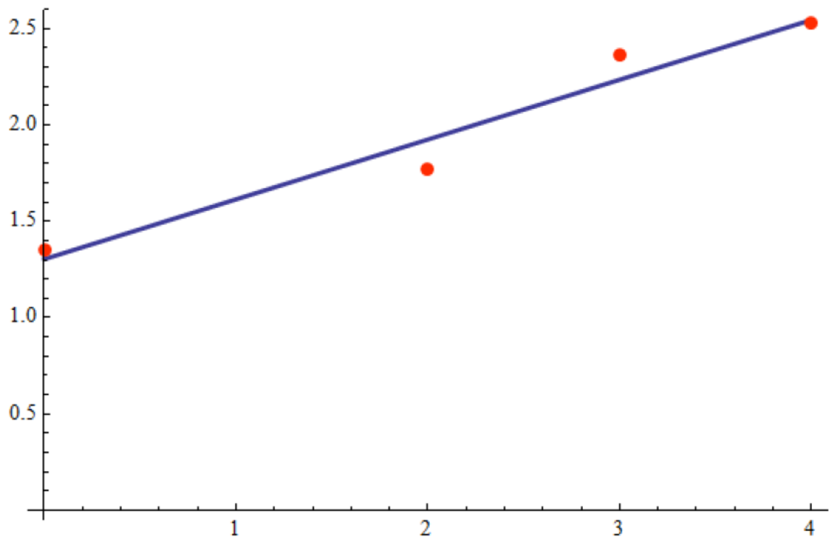
interpolation for forecasting one of the most important parameters$f$ (solidity of asphalt-concrete at compression at 50^{0}C). Because, as we know, $f$is essentially depended onx_1,$x_2$andx_3.Inverse interpolation may be also used, when we determine meanings of x_1,$x_2$andx_3 for getting intereseting meaning of f. It will give us an opportunity to plan experiment in advance.

II. Same problem has been solved byleast-squares method. Computer packet „Mathematica 8" has been still used.Outcomes of calculations are given below in Table N4.

	Calculated by mid-square method (with first row polynomial)			
5	1	89.86	47.571	1.614
6	1.2	87.76	48.2	1.676
7	2.5	74.13	52.286	2.08
8	3.5	63.64	55.43	2.39

Table N4. Outcomes obtained by usingmid-square method



Pic.1. Graph off(solidity of asphalt-concrete at compression at 50^{0}C)(Calculated by mid-square method (with first row polynomial))

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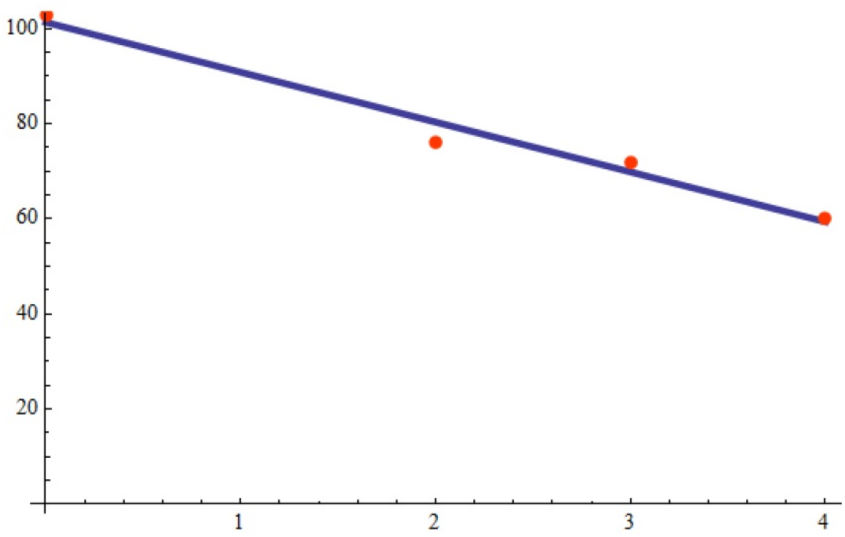
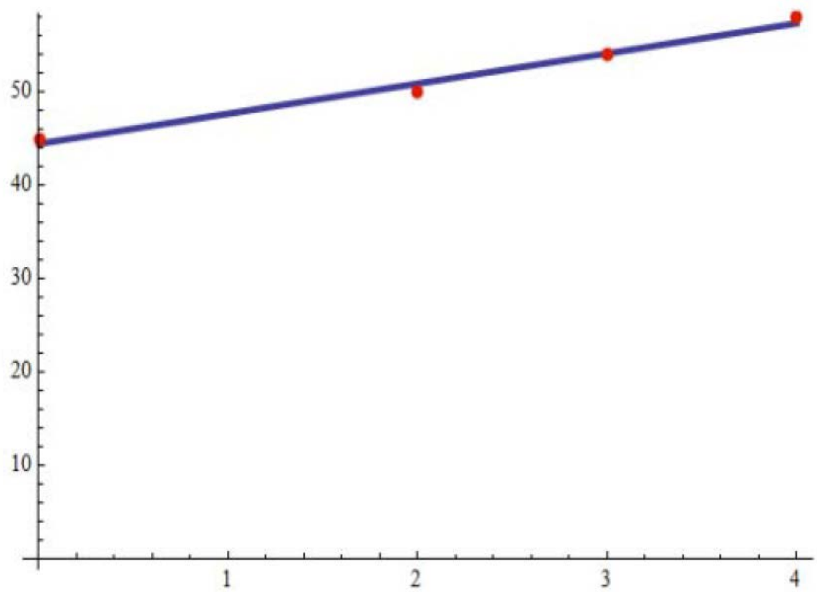


Pic.2. Graph of X2(penetration) (Calculated by mid-square method (with first row polynomial))



Pic.3. Graph of X3(softening temperature of bitumen) (Calculated by mid-square method (with first row polynomial))

As we see, results of experiment of $x_2(2.5)$, $x_3(2.5)$ and $f(2.5)$ are well agreed with the results obtained by calculations.

Use of least-squares method is especially expedient in that case when we have a deal with great number of data of physical experiment.

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