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Modelling of a thermal insulation system based on the coldest temperature conditions by using artificial neural networks to determine performance of building for wall types in Turkey

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ABSTRACT

In formation of building external envelope, as two important criteria, climatic data and wall types must be taken into consideration. In the selection of wall type, the thickness of thermal insulation layer (d_i) must be calculated. As a new approach, this study proposes determining the thermal insulation layer by using artificial neural network (ANN) technique. In this technique five different wall types in four different climatic regions in Turkey have been selected. The ANN was trained and tested by using MATLAB toolbox on a personal computer. As ANN input parameters, U_w, $T_{e,Met}$, $T_{e,TSE}$, R_{wt}, and q_{TSE} were used, while d_i was the output parameter. It was found that the maximum mean absolute percentage error (MRE, %) is less than 7.658%. R^2 (%) for the training data were found ranging about from 99.68 to 99.98 and R^2 for the testing data varied between 97.55 and 99.96. These results show that ANN model can be used as a reliable modeling method of d_i studies.

Modélisation d’un système d’isolation thermique fondée sur les températures les plus froides, à l’aide de réseaux neuronaux artificiels, afin de déterminer la performance de plusieurs types de murs d’immeubles en Turquie

Mots clés : Isolation ; Analyse thermique ; Mur ; Immeuble ; Refroidissement ; Réseau neuronal

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Nomenclature

d	target value
d_i	thickness of thermal insulation (m)
$d_{i,\min}$	minim thickness of thermal insulation (m)
$d_{i,\max}$	maximum thickness of thermal insulation (m)
d_{i11}	thickness of thermal insulation 1st type of wall for 1st region (m)
d_{i12}	thickness of thermal insulation 2nd type of wall for 1st region (m)
d_{i13}	thickness of thermal insulation 3rd type of wall for 1st region (m)
d_{i14}	thickness of thermal insulation 4th type of wall for 1st region (m)
d_{i15}	thickness of thermal insulation 5th type of wall for 1st region (m)
d_{i21}	thickness of thermal insulation 1st type of wall for 2nd region (m)
d_{i22}	thickness of thermal insulation 2nd type of wall for 2nd region (m)
d_{i23}	thickness of thermal insulation 3rd type of wall for 2nd region (m)
d_{i24}	thickness of thermal insulation 4th type of wall for 2nd region (m)
d_{i25}	thickness of thermal insulation 5th type of wall for 2nd region (m)
d_{i31}	thickness of thermal insulation 1st type of wall for 3rd region (m)
d_{i32}	thickness of thermal insulation 2nd type of wall for 3rd region (m)
d_{i33}	thickness of thermal insulation 3rd type of wall for 3rd region (m)
d_{i34}	thickness of thermal insulation 4th type of wall for 3rd region (m)
d_{i35}	thickness of thermal insulation 5th type of wall for 3rd region (m)
d_{i41}	thickness of thermal insulation 1st type of wall for 4th region (m)
d_{i42}	thickness of thermal insulation 2nd type of wall for 4th region (m)
d_{i43}	thickness of thermal insulation 3rd type of wall for 4th region (m)
d_{i44}	thickness of thermal insulation 4th type of wall for 4th region (m)
d_{i45}	thickness of thermal insulation 5th type of wall for 4th region (m)
k	thermal conductivity(W m^{-1} K^{-1})
q_{TSE}	heat transfer rate of TSE (kJ)
MRE	mean relative error
p	pattern
R	overall thermal resistance value (m^2 KW^{-1})
R_i	inner surfaces thermal resistance value (m^2 KW^{-1})
R_{in}	insulation material thermal resistance value (m^2 KW^{-1})
RMS	root-mean square
R_o	outer surfaces thermal resistance value (m^2 KW^{-1})
R_w	wall thermal resistance value (m^2 KW^{-1})
R_{wt}	total wall thermal resistance (m^2 KW^{-1})
R^2	absolute fraction of variance
R^2_{11}	absolute fraction of variance of 1st type of wall for 1st thermal region
R^2_{12}	absolute fraction of variance of 2nd type of wall for 1st thermal region
R^2_{13}	absolute fraction of variance of 3rd type of wall for 1st thermal region
R^2_{14}	absolute fraction of variance of 4th type of wall for 1st thermal region
R^2_{15}	absolute fraction of variance of 5th type of wall for 1st thermal region
R^2_{21}	absolute fraction of variance of 1st type of wall for 2nd thermal region
R^2_{22}	absolute fraction of variance of 2nd type of wall for 2nd thermal region
R^2_{23}	absolute fraction of variance of 3rd type of wall for 2nd thermal region
R^2_{24}	absolute fraction of variance of 4th type of wall for 2nd thermal region
R^2_{25}	absolute fraction of variance of 5th type of wall for 2nd thermal region
R^2_{31}	absolute fraction of variance of 1st type of wall for 3rd thermal region
R^2_{32}	absolute fraction of variance of 2nd type of wall for 3rd thermal region
R^2_{33}	absolute fraction of variance of 3rd type of wall for 3rd thermal region
R^2_{34}	absolute fraction of variance of 4th type of wall for 3rd thermal region
R^2_{35}	absolute fraction of variance of 5th type of wall for 3rd thermal region
R^2_{41}	absolute fraction of variance of 1st type of wall for 4th thermal region
R^2_{42}	absolute fraction of variance of 2nd type of wall for 4th thermal region
R^2_{43}	absolute fraction of variance of 3rd type of wall for 4th thermal region
R^2_{44}	absolute fraction of variance of 4th type of wall for 4th thermal region
R^2_{45}	absolute fraction of variance of 5th type of wall for 4th thermal region
$T_{e,Met}$	lowest temperatures in meteorological data, °C
$T_{e,TSE}$	lowest temperatures in TSE data, °C
T_i	inner temperature (K)
T_o	outer temperature (K)
TS 825	Turkish Standard (thermal insulation requirements for buildings)
U	overall heat transfer coefficient (W m^{-2} K^{-1})
U_w	maximum overall heat transfer coefficient (W m^{-2} K^{-1})
x	thickness of the insulation material (m)
Z	real value in a parameter
$Z_{\max}$	maximum value of Z
$Z_{\min}$	minimum value of Z
Z_N	normalized value of Z

Subscripts

i	inner
in	insulation
o	outer
w	wall