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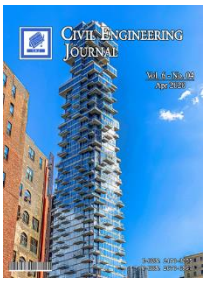

# Numerical Study on RC Multilayer Perforation with Application to GA-BP Neural Network Investigation

Weiwei Sun [a], Ze Shi [b], Bingcheng Chen [a], Jun Feng [c*]

[a] *Department of Civil Engineering, Nanjing University of Science and Technology, Nanjing 210094, China.*

[b] *State Key Laboratory of Explosion Science and Technology, Beijing Institute of Technology, Beijing 100081, China.*

[c] *National Key Laboratory of Transient Physics, Nanjing University of Science and Technology, Nanjing 210094, China.*

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**Abstract**

The finite element model of projectile penetrating multi-layered reinforced concrete target was established via LS-DYNA solver. The penetration model was validated with the test data in terms of residual velocity and deflection angle. Parametric analyses were carried out through the verified penetration model. Seven influential factors for penetration conditions, including the initial velocity of projectile, initial angle of attack of projectile, initial dip angle of projectile, the first layer thickness of concrete target, the residual layer thickness of concrete target, target distance and the layer number of concrete target, were put emphasis on further analysis. Furthermore, the influence of foregoing factors on residual velocity and deflection angle of projectile were numerically obtained and discussed. Based on genetic algorithm, the BP neural network model was trained by 263 sets of data obtained from the parametric analyses, whereby the prediction models of residual velocity and attitude angle of projectile under different penetration conditions were achieved. The error between the prediction data obtained by this model and the reserved 13 sets of test data is found to be negligible.

*Keywords:* Multi-layered Concrete Plates; Oblique Penetration; Deflection Angle; Neural Network Model.

## 1. Introduction

Since the Kosovo and Iraq wars, precision-guided ground-drilling weapons represented by the US Army's 'Jedam' ground-drilling missiles have developed rapidly. Researches on the damage of underground multi-story fortifications need to explore the deep mechanism of the penetration and perforation into multi-layer reinforced concrete targets [1-3]. The better understanding over projectile perforation into multi-layer RC panels may contribute to the design and construction of high-performance shelter.

At present, there is still a lack of research on multi-parameter systems for the problem of missiles penetrating multilayer reinforced concrete targets. Yue et al. [4] established a numerical calculation model of steel bullets penetrating multilayer spacer targets, and obtained the influence of the geometry, density, and mass of steel bullets on the penetration response of 5-layer spacer targets. Ji et al. [5] carried out numerical calculations on the projectile penetrating three layers of homogeneous steel plates, and obtained the velocity and acceleration change curves of the projectile, and simulated the residual velocity of the projectile perforating the three-layer target plate. Liu and Huang carried out LS-DYNA simulation research on the basis of the experiments of the projectile penetrating the three-layer

* Corresponding author: jun.feng@njust.edu.cn

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