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Research Article

ROTOR TURBULENCE INFLUENCE ON HELICOPTER FLIGHTS IN HIGH URBAN BUILT-UP AREA

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ABSTRACT
The paper provides a discussion of the influence of turbulence in the areaa of high urban buildings or in vicinity of fire on safety of helicopter flights. The analysis was conducted using Ansys Fluent software. All the threats considering helicopter flight, landing and hovering in such an environment were shown. As objects of this research helicopter types: W3-A Sokół, W3-A Głuszec and Robinson R-44 were used.

Keywords: helicopter, rotor, turbulence, urban area.

INTRODUCTION

The purpose of this publication is to reveal the threats associated with light helicopter flights in air turbulence induced by building flow round or different types of fires [1, 3]. This work also defines an effect of disturbances due to the resultant of flow interference generators (such as rotor blades, fuselage solids, suspended components and fixed lift generating surfaces) on their loads, dynamics of motion and operational parameters of the helicopter [2, 4]. Dealing with this issue contributed to explanation of previously unrecognized phenomena which have significant impact on helicopter glide ratio or safety during flight in particular conditions as appearance of vortex ring state on lift or tail rotor, flow separation either on rotor blades and fixed lift surfaces or field interference induced by helicopter rotors with obstacles located in the vicinity of flight path (e.g. with ship deck, shape of buildings, nearby which rescue operations are conducted or during take-offs and landings on elevated heliports such as oil rigs and hospitals).

METHODS

Appropriate computational-experimental tools were developed to enable solving aerodynamic and operating problems and thus upgrade helicopters' design and modify nowadays. In model using Navier-Stokes equation solutions, an area of turbulent, disturbed medium flow was determined, introducing only geometrical parameters of environment solids (including helicopter) and models of rotors defined as active step of pressure generators. In order to conduct an accurate analysis of selected aspects of aerodynamic interference the real helicopter model was replaced by a vortex model.

Flow interference around a helicopter is an interaction between disturbances caused by wake turbulence of rotors, fixed lift surfaces, such as stabilizers and auxiliary wing, and presence of fuselage solid. Physical helicopter model used to examine interference issues, for assessment disturbances of field flow using uniform Biot-Savart method, was replaced by vortex meshwork. Another approach concerns mixed methods e.g. flow potential for assessing fuselage flow round. Fuselage, for vortex model is featured as system of vortex panels, and lift generating components as vortex mesh which generates flow field velocity disturbances. Using capabilities of the featured methods, including modal models of rotors and lift surfaces loads, modified in every step of the related vortexes intensity; the presented equation constitutes an interference resolving essence in non-stationary motion of a helicopter. A load waveform in the function of time is also an outcome of the project.

RESULTS

Numerical calculations of the influence aerodynamic interference on helicopter loads were conducted in two stages. For the assumed pressure distribution on rotor (in the first approximation constant distribution was assumed), using FLUENT software, helicopter flow round was determined with consideration for objects in close vicinity. Thus velocity field of flow across the plane of rotor was determined. Subsequently using OBCWN software (developed in Institute of Aviation, Warsaw, and then accordingly modified to meet the requirements of aerodynamic interference analysis) to determine rotor loads. Using this introduced airflow, rotor load characteristics and new pressure distribution o its surface were determined. New pressure distribution was introduced for the recalculation of helicopter flow round in FLUENT software for compensation (Fig. 1-2).

Iteration process was conducted until results' concurrence was obtained. In order to expedite concurrence process, flow velocity field, being an average of previous iteration and current calculations was loaded for subsequent iterations. For rotor blade of high elasticity such exertion was vital due to the significant blade sensitivity for disturbance in the form of blade deflection function. With such an intervention, satisfactory concurrence was obtained in the second calculations step. Numerical calculations of main rotor loads were conducted for a given flow field, calculated with FLUENT software (Fig. 3-4).

Thanks to coupling the results from FLUENT software with OBCWN software, used to determine main rotor blades loads and deformations,

a) b)

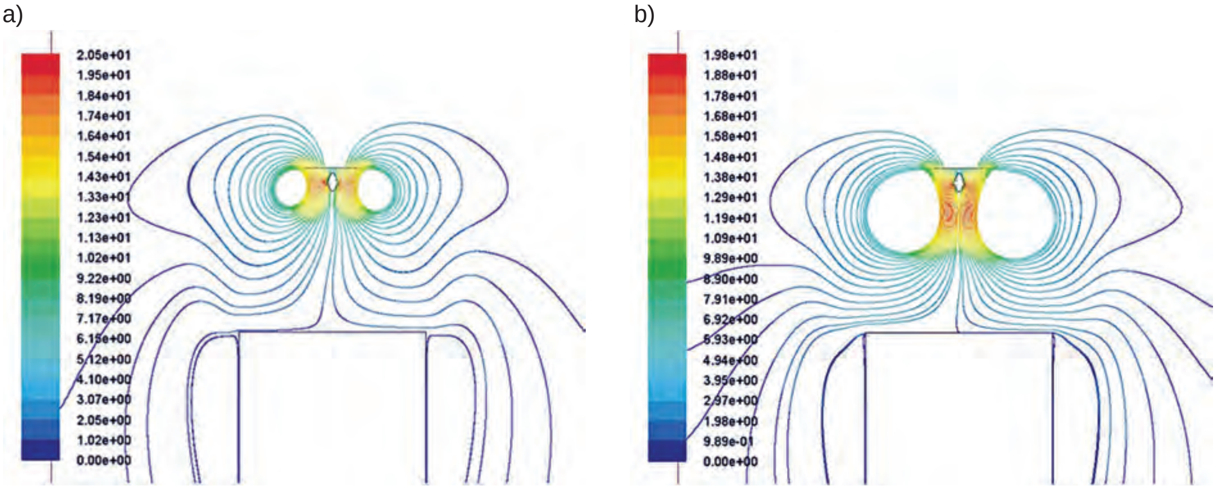

Fig. 1. Disturbances caused by helicopter in case of operating above building:
a) hovering above building, b) approach for landing on a platform-disturbances of walls flow round view

a) b)

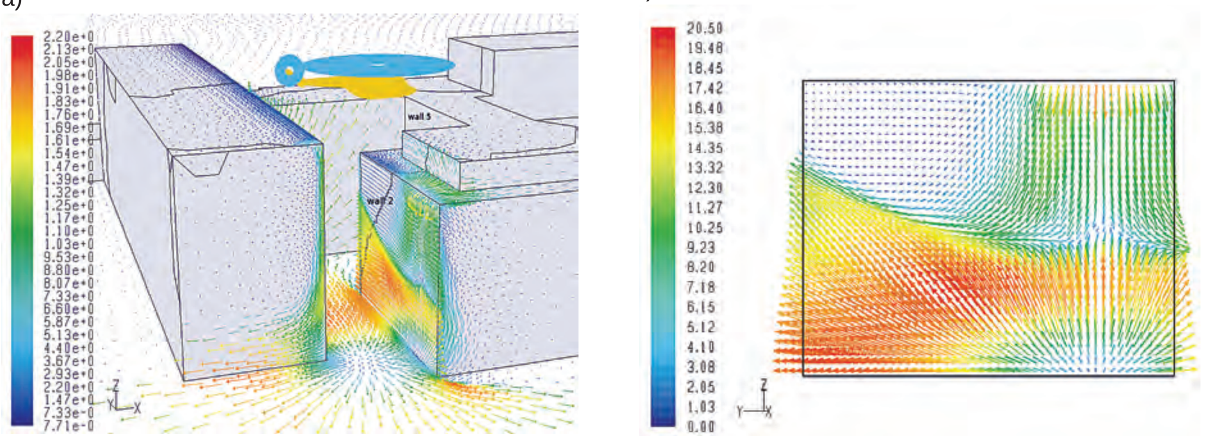

Fig. 2. Another view with walls designations and wall nr 2 flow round view

a) b)

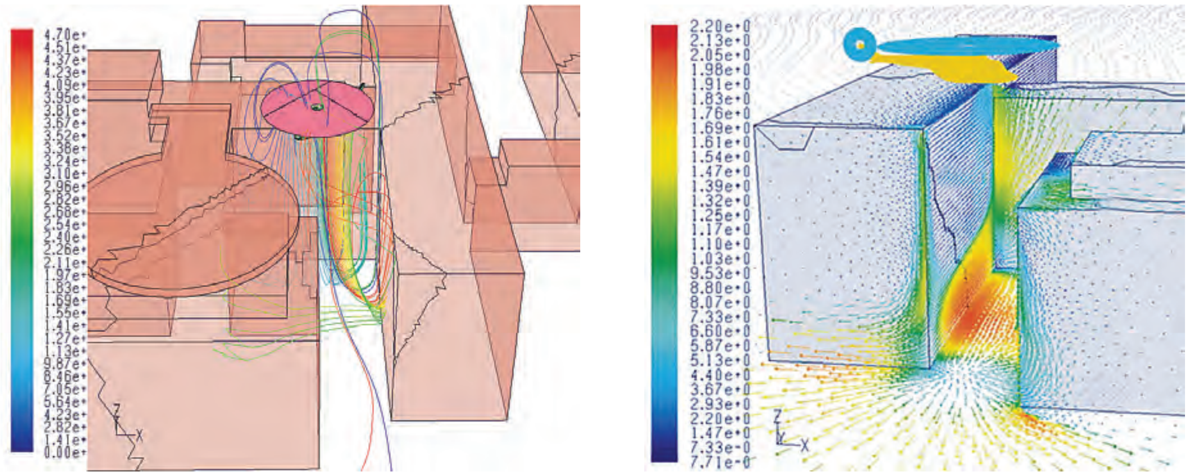

Fig. 3. Disturbances caused by helicopter during roof helipad operations: a) approach for landing on a platform, b) view of building walls flow round disturbances

a) b)

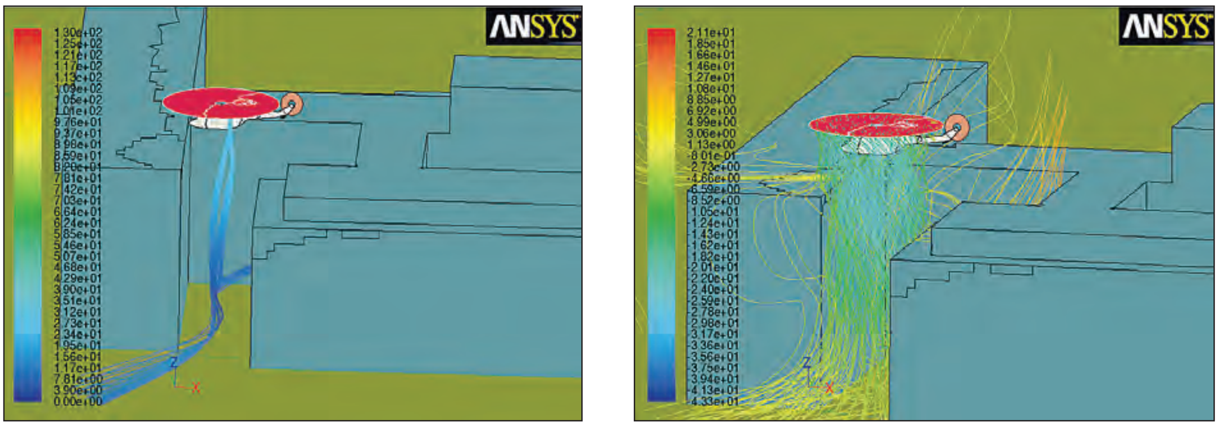

Fig. 4. Disturbances caused by helicopter during roof helipad operations: a) exhaust streams from engine nozzles, b) rotor stream lines flowing building around

the problem of aerodynamic interference can be analyzed. Thanks to this calculations algorithm, it was possible to analyze rotors with blades of different mass-stiffness and aerodynamic characteristics. For a given moment of time, motion parameters and blades loads, located at various azimuths on rotor disc, were determined. After summing impacts of all the blades, rotor shaft strain, for this particular moment of time, was determined. Aeroelastic blades deformation, aerodynamic load of single blades, net forces of rotor loads and the whole helicopter system, were obtained, using OBCWN software. Empirical studies, using real object – W3-A "Sokół" helicopter, were conducted at PZL Świdnik S.A. factory aerodrome.

SUMMARY

The characteristics of velocity field distribution of main rotor downwash, during hovering at a low altitude, were obtained. The results from researches, mentioned above, were used in comparative analysis with computer simulations results. There were also researches conducted in Nowy Glinnik Air Force Base, using two W3-A "Głuszec" helicopters, during which, horizontal component of downwash characteristics were obtained for interference phenomenon between two helicopters during take-off phase.

The results of the studies on interference phenomenon, may also conduce in helicopter design stage and for aerodynamic characteristics improvement. Thus, by proper selection of system parameters, helicopter's performance may be enhanced and some improvement can be noticed in noise abatement or comfort e.g. lower vibration level. Another area where interference research is vital is the area of pilots operating helicopters. Helicopter flights in high urban build-up agglomeration territory or in the mountains causes nowadays situations, in which helicopter flight in very close vicinity to obstacles of various shapes is necessary. This area will be a further stage of scientific research in the future. Additional influence of wind may cause significant amplification of helicopter aerodynamic interference and may also worsen flight characteristics or lead to dangerous situations.

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