

STUDY ON COHERENT VORTEX STRUCTURES OVER DUNE TYPE WAVY BED IN AN OPEN-CHANNEL FLOW BY DNS

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In this study, fully developed three-dimensional turbulent flow over plural solid dune bed in an open-channel was reproduced by direct numerical simulation (DNS). Its coherent structures were also examined using time-line technique and identification of cylindrical vortex tubes. "Boil of the first kind", which was unique to the flow field on dune-type sand wave, was numerically reproduced. It was found that kolk which causes boil of the first kind can be detected as cylindrical vortex tubes rising from the bed. It was also found that boil of first kind and kolk were generated not only from "hairpin vortices (Fig.1)" as conventionally noted but also from "reverse hairpin vortices(Fig.2)" with their head near the bed and cyclonic vortices at their foot. The following findings were obtained:

- (1) DNS was applied to flow fields over dune-type sand waves. Existing experimental results, including mean flow characteristics, reattachment point, and boils characteristic of such flow fields, were reproduced.
- (2) Kolk vortices, which can be identified as tubular vortices arising from the riverbed, are characterized by rapid attenuation of rotation and induction of compensating vortices near the free surface. This interaction is reflected in the elliptical shape of boil extending downstream on the free surface.
- (3) Boils of the first kind and their causal kolk vortices are generated from "reverse hairpin vortices(Fig.2)" whose head is near the bed and cyclonic vortices at their legs.

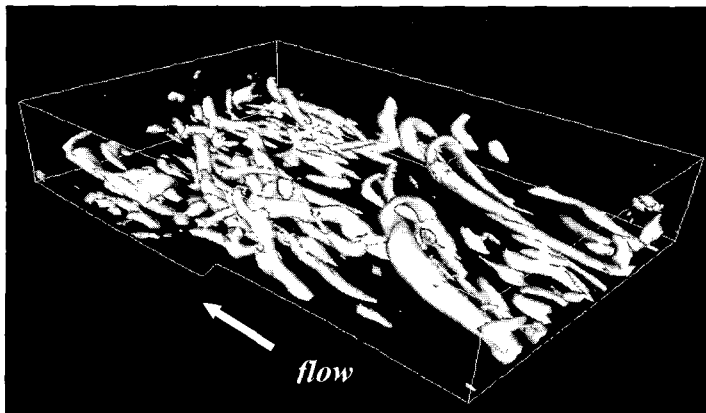


Fig. 1 Visualized coherent vortex structures "hairpin vortices" over a dune-type bed

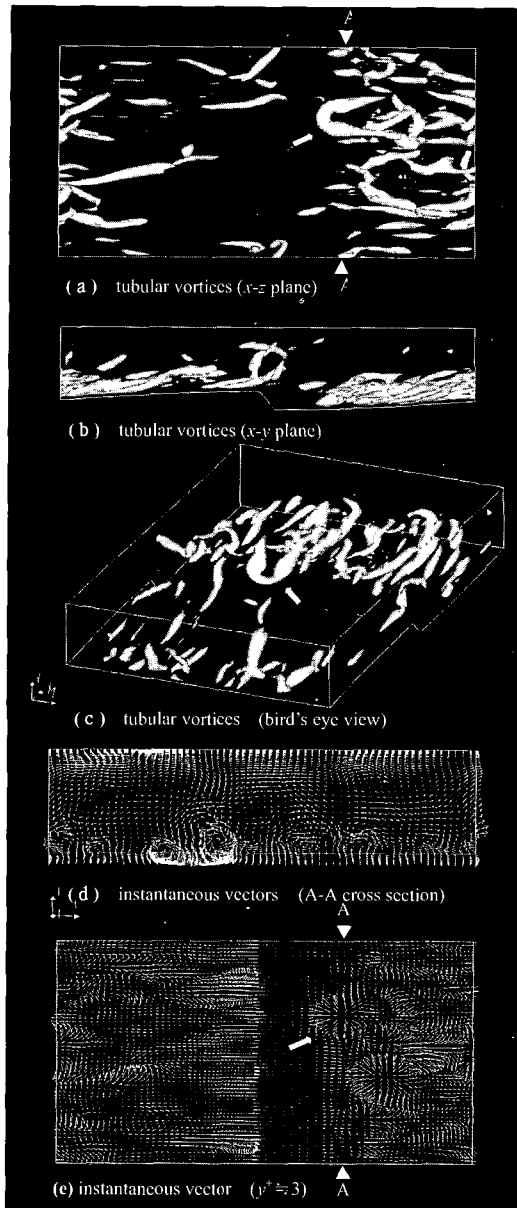


Fig. 2 Visualized coherent vortex structures "reverse hairpin vortices"