NONLINEAR OBLIQUE INTERACTION OF LARGE AMPLITUDE INTERNAL SOLITARY WAVES

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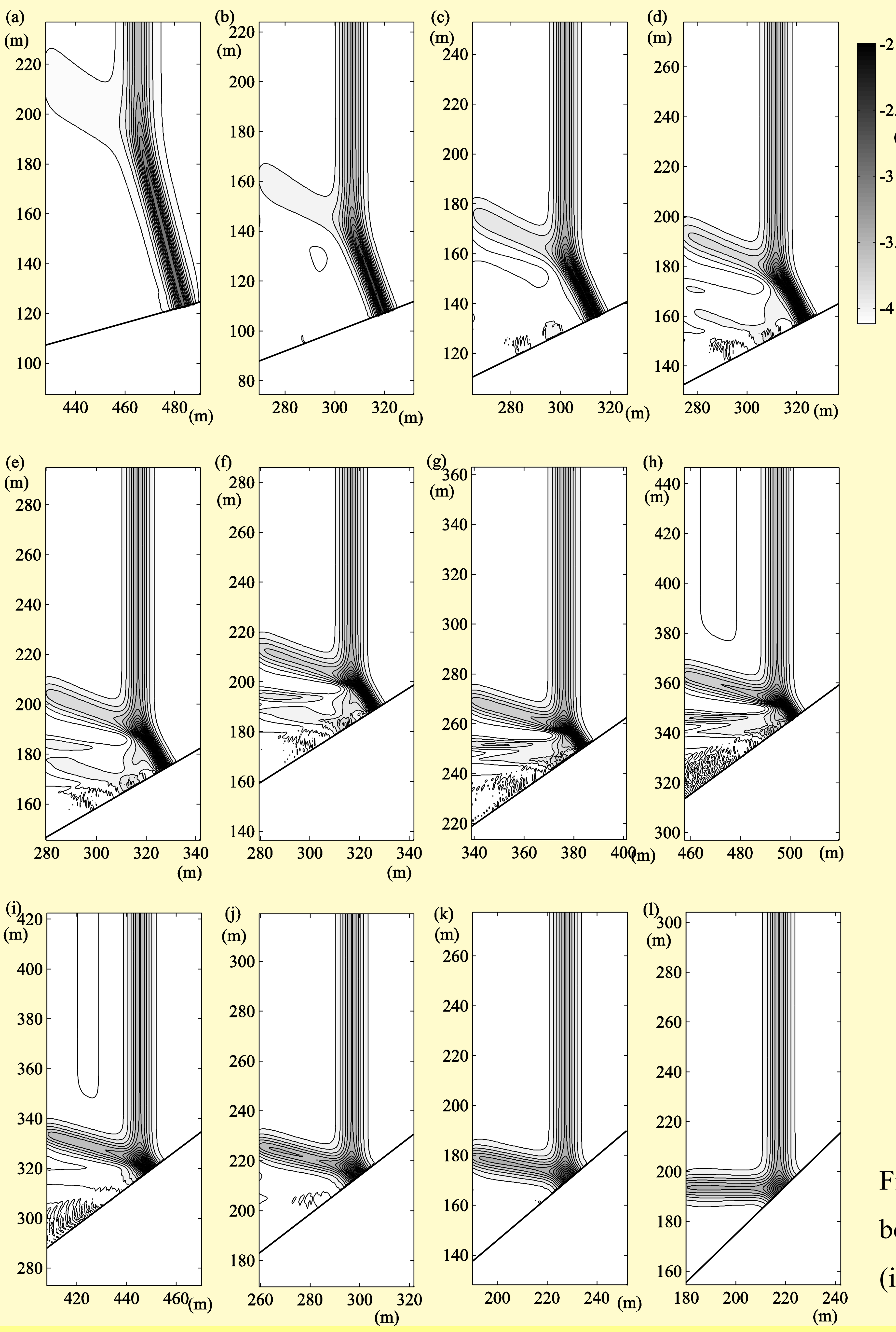
1. Introduction

When tsunamis propagate into shallow water regions around a coast, they may deform into a train of solitary waves due to the nonlinear shallow water deformation. Also, when solitary waves progress into a river, the change in the river width is expected to cause resonance of solitary waves along the oblique riverbank. In the previous studies, large amplitude solitary waves are found to be induced by solitary resonance, which may be on of the 'freak waves' in the ocean. Tsuji and Oikawa (2006) and Funakoshi (1980) revealed that solitary resonance amplifies a wave several times relative to the original wave with the occurrence of "stem" by using a weekly nonlinear wave model in a two-dimensional domain. "stem" is found to appear when the incident wave angle is less than the critical angle, which was derived by Miles (1977). However, the mechanisms of the occurrence of such waves have not been clarified when river tsunami propagates in a river. This study thus aims to investigate the deformation of solitary waves in a shallow water region around a coast and the resonance due to the oblique boundary in a river. The aim of this study is to investigate the strongly nonlinear interaction of river tsunamis.

2. Methods and Results

The third-order internal solitary wave equations based on the ninth-order solitary wave equations (Mirie & Pennell, 1989) was derived in order to give an initial condition of strongly nonlinear internal solitary wave. Firstly, nonlinear deformation was confirmed to induce large amplitude solitary waves when the waves propagate from offshore to a river mouth. Secondly, the resonance of solitary waves due to oblique boundary conditions was investigated by using the computational domain proposed by Funakoshi (1980). The water depth was 2 m and the wave height was given as 0.5 m, respectively. Computations were conducted for 12 cases, in which the incident wave angle ranged from 15 to 45 degrees. To save computational time, the actual computational region was limited to the 150 meshes around the incident internal solitary wave, which corresponds to 60 m in the x coordinate (Figure 1). Elsewhere, a sponge layer was applied to reduce the reflection from the outside of the actual computational region. Also, parallel computing was applied by using 12 CPUs.



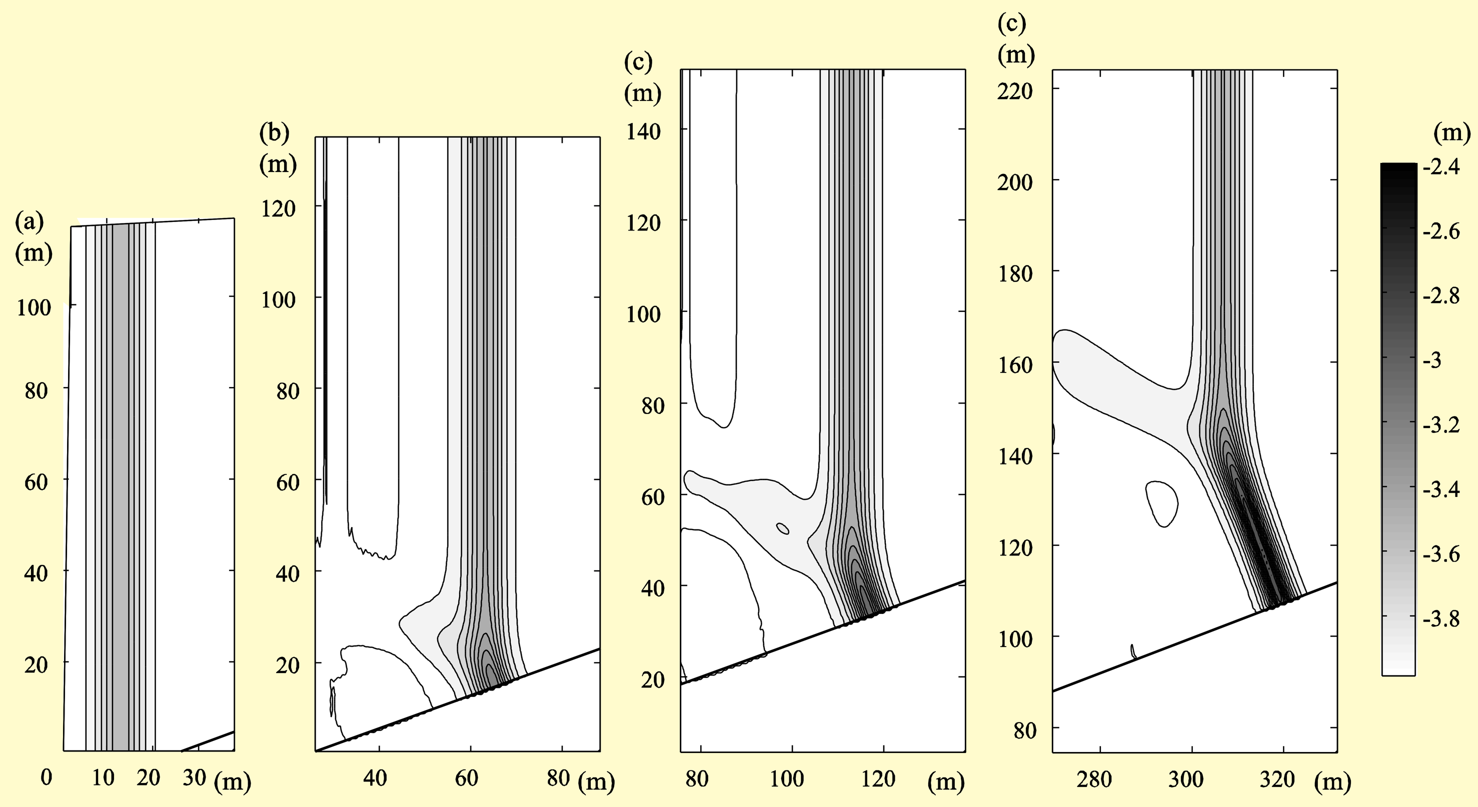


Fig. 1 Deformation of solitary waves when the incident angle is 20 degrees. (a) 0 sec, (b) 10 sec, (c) 20 sec, and (d) 59 sec.

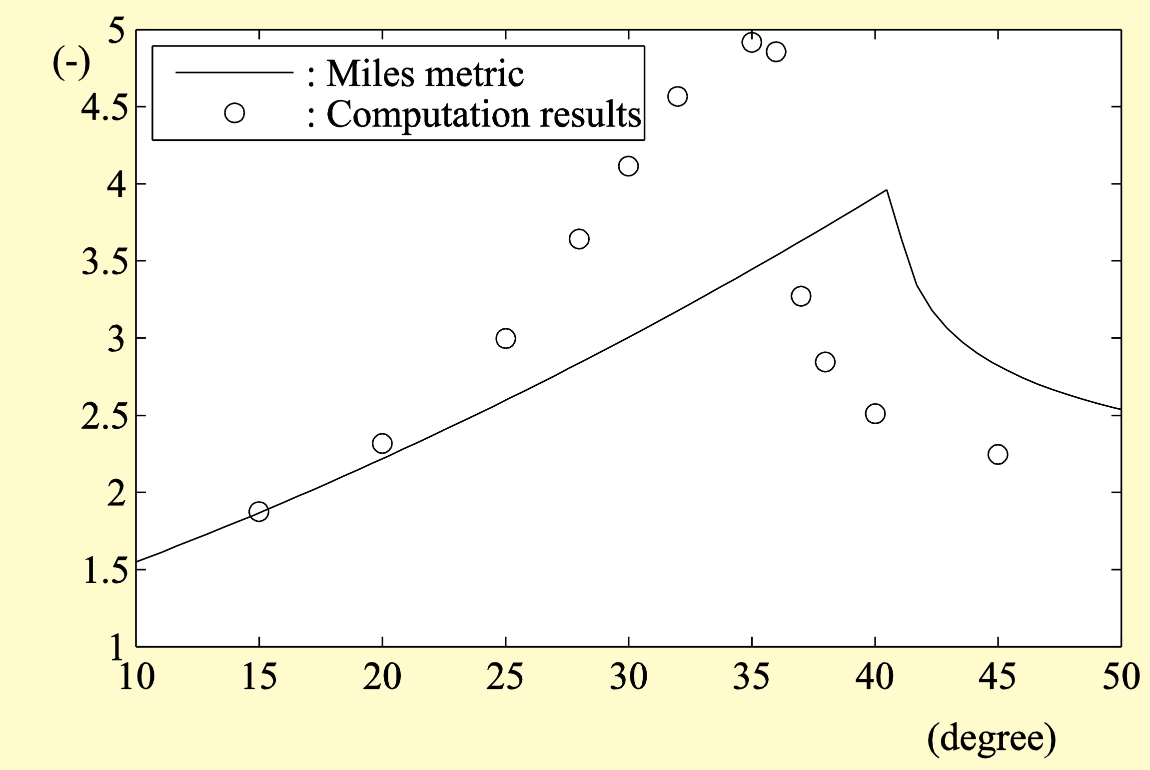


Fig. 3 Amplification rate of solitary waves and Mile' s solutions.

Fig. 2 Deformation of a solitary wave when the angles of an oblique boundary are (a)15, (b)20, (c)25, (d)28, (e)30, (f)32, (g)35, (h)36, (i)37, (j)38, (k)40, and (l)45, respectively.

3. References

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