

Highlights

1. The breather wave is derived by setting a nonzero background on the obtained N -solitary wave of the $(2 + 1)$ -dimensional generalized fifth-order KdV equation.
2. By applying the velocity resonance mechanism and transformed wave conditions to the N -solitary wave solutions, abundant nonlinear wave structures and its transition phenomenon are constructed and analyzed.
3. Molecular structures composed of the asymmetric M -Shaped soliton, the W -Shaped soliton, and other different nonlinear waves are formed by virtue of velocity resonance ansatz.
4. We also discussed the dynamic behaviours of novel nonlinear wave and molecule structures through the phase shifts and the trajectory equations.
5. The combined methods adopted in this article can be used to investigate the related nonlinear wave phenomena in other nonlinear systems.