A new eddy-viscosity closure is proposed for the subgrid-scale (SGS) stress tensor in large-eddy simulation of transitional and turbulent flows. Based on the SGS helicity dissipation balance in helical turbulence, the spectral relative helicity relation, and the joint energy and helicity spectra, the new form of SGS model is deduced in theory. The eddy-viscosity is shown to be proportional to the product of the large-scale velocity strain rate tensor and the symmetric part of the large-scale vorticity gradient (or vorticity strain rate tensor). The new SGS model is first tested and validated in simulation of incompressible channel flows. The statistical results demonstrate that the present model can predict both the mean velocity profile and the mean skin-friction coefficient curve more precisely than the dynamic Smagorinsky model (DSM) and a mixed helical model as compared with the results calculated in direct numerical simulation (DNS). Then, a compressible version of the new SGS model is parameterized and utilized to simulate the compressible flow past a circular cylinder. It is found that the the present eddy-viscosity model can reproduce the skin friction force much more accurately than the standard Smagorinsky model, and can simulate more realistic flow structures in the near wake of the cylinder than the detached-eddy simulation (DES) approach. The surprising findings in simulation of compressible flat-plate flow, the SGS model can predict the transitional location and the transitional peak precisely.