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FRACTAL DIMENSION AS A CHARACTIRISTIC OF FRACTURE

Marina M. Davydova

[1] Institute of Continuous Media Mechanics Russian Academy of Sciences
1 Ak. Korolev str., 614013 Perm, Russia
davydova@icmm.ru, www.icmm.ru

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This work presents two examples illustrating the use of the fractal concept in studying different aspects of fracture: (i) the percolation model of failure cluster growth; (ii) the analysis of fracture patterns resulting from glass fragmentation.

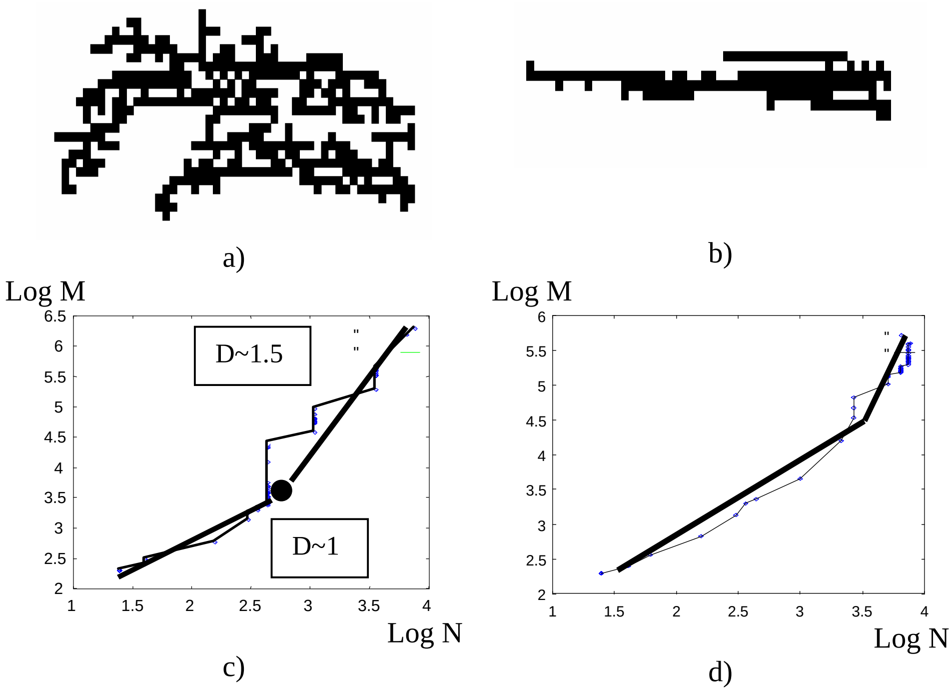

Fig. 1. a) Branched and b) weakly branched clusters. c) Determination of fractal dimension for branched and d) weakly branched clusters.

The percolation model of failure cluster growth (based on the finite element method) [1] is a tool to investigate the transition from damage to fracture. Topological features of fracture are examined for localization and crack branching evolution problems. The cluster is fractal and its mass is defined as $\boldsymbol{M(L) \sim L^{D}}$, where L is the linear box size (box counting method) and D is the fractal dimension. The kinetics and topology of the cluster depend on (i) the form of kinetic equation of damage accumulation, (ii) loading conditions, (iii) the presence and size of the initial macrodefect. The combination of the above conditions may lead to formation of the branched (Fig.1a) or wealky branched cluster (Fig.1b). Simulation of fracture in the specimen with the initial defect shows that the graph $M(L)$ consists of two parts. The first part corresponds to fracture of the elements located in the vicinity of the initial defect ($D=1$). The percolation cluster crossing the specimen results from the coalescence of the cluster originating from the initial defect with the neighbour clusters ($D = 1.4 - 1.7$). This is indicative of the change in the damage topology and fracture type.

The statistics of fragmentation is studied in experiments on thin glass plates under quasi-static loads. The photo imaging and computer processing technique are used to calculate the fragment areas and the total crack length. The analysis of fragmentation patterns shows that the fault patterns are self-similar, and the total length $\boldsymbol{L}(\boldsymbol{r})$ of the cracks in a box of the size $\boldsymbol{r}*\boldsymbol{r}$ can be fitted by the power law $\boldsymbol{L}(\boldsymbol{r}) \sim \boldsymbol{r}^{\boldsymbol{D}}$ with the fractal dimension $1{,}59 < \boldsymbol{D} < 1{,}83$. It was suggested to characterize the transition from central zone (which looks like a flower) to the zone with more homogeneous fragments (fig.2b) by the relation between the total crack length $\boldsymbol{L}(\boldsymbol{S})$ inside the square frame of thickness $\boldsymbol{h}$ and the frame area $\boldsymbol{S}$ written as a power law $\boldsymbol{L}(\boldsymbol{S}) \sim \boldsymbol{S}^{\boldsymbol{D}}$. The log-log representation of $\boldsymbol{L}(\boldsymbol{S})$ changes a slope and the power-law exponent $\boldsymbol{D}$ decreases for the crack patterns occurring under high pressure conditions

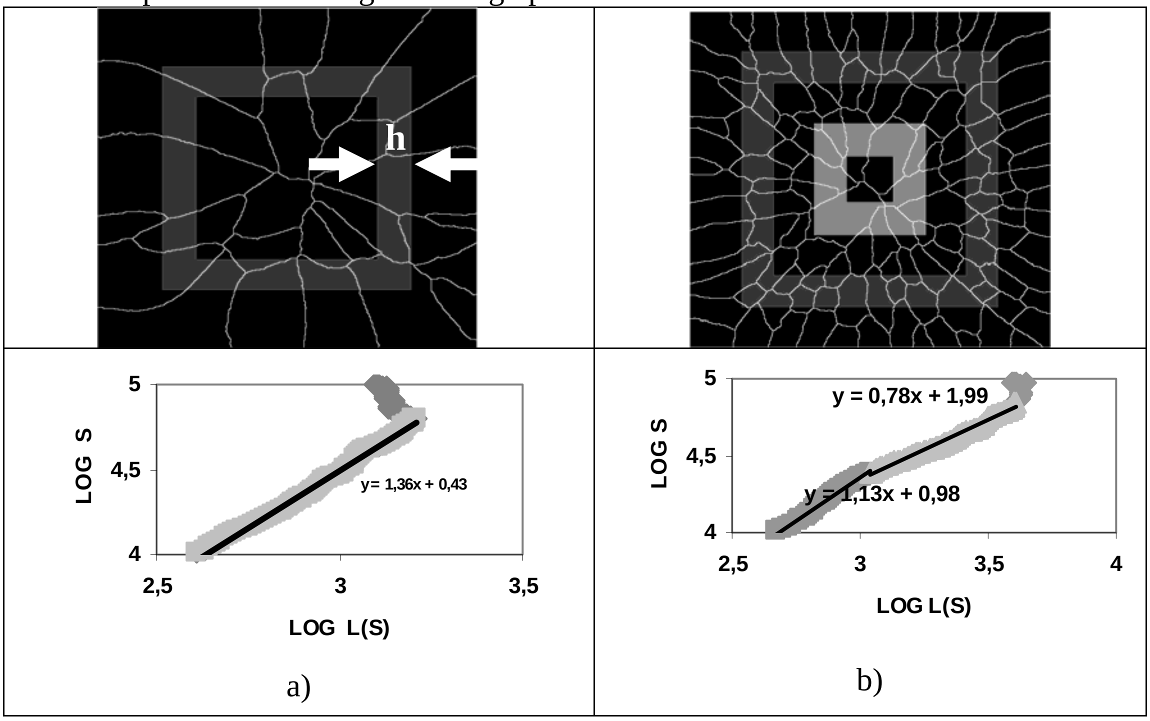

Fig. 2. a) Fractal charts calculated by using the relation $\boldsymbol{L}(\boldsymbol{S}) \sim \boldsymbol{S}^{\boldsymbol{D}}$ for pressure lower than $4*10^5$ N/m^2 ; b) higher than $4*10^5$N/m^2.

From the above examples we can draw a conclusion that the fractal dimensions can be used to characterize the fracture type. In both these cases the variation in the fracture mechanism correlates with quantitative changes in the fractal dimension.

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