

Wzory na szczeliny zastępcze dla kilku niesymetrycznych układów cewek o praktycznym znaczeniu

|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I    | <p>Wzory w postaci ogólnej</p> | $1. \delta' = \Delta_0 \left( \frac{m}{N} c_l \right)^2 + \Delta_N \left( \frac{n-m}{N} c_l \right)^2 + \sum_{k=1}^{N-1} \Delta_k \left( \frac{m}{N} c_l - \frac{k}{N} c_l \right)^2 + \sum_{k=1}^{n-m} \delta_k \left( \frac{k}{N} c_l \right)^2 + \frac{1}{3} \left( \sum_{k=1}^N A_k c_k^2 + \sum_{k=1}^n a_k c_k^2 \right) + \sum_{k=1}^N A_k \left( \frac{m}{N} c_l - \frac{k}{N} c_l \right) \left( \frac{m}{N} c_l - \frac{k}{N} c_l \right) + \sum_{k=1}^n a_k \left( \frac{k}{N} c_l - \frac{k}{N} c_l \right) \left( \frac{k}{N} c_l - \frac{k}{N} c_l \right) + \sum_{k=1}^n a_k \left( \frac{k}{N} c_l - \frac{k}{N} c_l \right) \left( \frac{k}{N} c_l - \frac{k}{N} c_l \right)$ $2. \delta' = \Delta_0 \left( \frac{m}{N} \right)^2 + \Delta_N \left( \frac{n-m}{N} \right)^2 + \sum_{k=1}^{N-1} \Delta_k \left( \frac{m}{N} - \frac{k}{N} \right)^2 + \sum_{k=1}^{n-m} \delta_k \left( \frac{k}{N} \right)^2 + \frac{1}{3} \left( \sum_{k=1}^N A_k + \sum_{k=1}^n a_k \right) + \sum_{k=1}^N A_k \left( \frac{m}{N} - \frac{k}{N} \right) \left( \frac{m}{N} - \frac{k}{N} \right) + \sum_{k=1}^n a_k \left( \frac{k}{N} - \frac{k}{N} \right) \left( \frac{k}{N} - \frac{k}{N} \right) + \sum_{k=1}^n a_k \left( \frac{k}{N} - \frac{k}{N} \right) \left( \frac{k}{N} - \frac{k}{N} \right)$ $3. \delta' = \Delta_0 \left( \frac{m}{N} \right)^2 + \Delta_N \left( \frac{n-m}{N} \right)^2 + \Delta \left( N-1 \right) \left[ \frac{2N-1}{6N} - \frac{m}{N} \left( 1 - \frac{m}{N} \right) \right] + \delta \left( n-1 \right) \left[ \frac{2n-1}{6n} - \frac{m}{n} \left( 1 - \frac{m}{n} \right) \right] + \frac{AN + an}{3} \left[ 1 - 3 \frac{m}{n} \left( 1 - \frac{m}{n} \right) \right]$ |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| II   |                                | $m=1$ $n=3$ $N=3$ $1. \delta' = \Delta_0 c_l^2 + \Delta_N (1-c_l)^2 + \Delta_1 (c_l - c_l)^2 + \Delta_2 (c_l - 1 + c_3)^2 + \delta_2 c_3^2 + \frac{1}{3} (A_1 c_l^2 + A_2 c_l^2 + A_3 c_l^2 + a_1 c_l^2 + a_2 c_l^2 + a_3 c_l^2) + A_1 c_l (c_l - c_l) + A_2 c_l (c_l - c_l) + A_3 c_l (c_l - c_l) + a_2 (c_2 + c_3) c_3$ $2. \delta' = \frac{1}{9} (\Delta_0 + 4\Delta_N + \Delta_2 + \delta_2 + \frac{A_1 + A_2 + 7A_3}{3} + \frac{a_1 + 7a_2 + a_3}{3})$ $3. \delta' = \frac{1}{3} \left( \frac{\Delta_0 + 4\Delta_N}{3} + \frac{\Delta + \delta}{3} + A + a \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| III  |                                | $m=1$ $n=3$ $N=4$ $1. \delta' = \Delta_0 c_l^2 + \Delta_N (1-c_l)^2 + \Delta_1 (c_l - c_l)^2 + \Delta_2 [c_l - (c_l + c_2)]^2 + \Delta_3 (c_l - 1 + c_4)^2 + \delta_2 c_3^2 + \frac{1}{3} (A_1 c_l^2 + A_2 c_l^2 + A_3 c_l^2 + A_4 c_l^2 + a_1 c_l^2 + a_2 c_l^2 + a_3 c_l^2) + A_1 c_l (c_l - c_l) + A_2 c_l (c_l - c_l) + A_3 c_l (c_l - c_l) + A_4 c_l (c_l - c_l) + a_2 (c_2 + c_3) c_3$ $2. \delta' = \frac{1}{9} (\Delta_0 + 4\Delta_N + \frac{\Delta_1 + 4\Delta_2 + 25\Delta_3}{16} + \delta_2 + \frac{7A_1 + A_2 + 13A_3 + 43A_4}{16} + \frac{a_1 + 7a_2 + a_3}{3})$ $3. \delta' = \frac{1}{3} \left( \frac{\Delta_0 + 4\Delta_N}{3} + \frac{5\Delta}{8} + \frac{\delta}{3} + \frac{4A + 3a}{3} \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| IV   |                                | $m=1$ $n=4$ $N=4$ $1. \delta' = \Delta_0 c_l^2 + \Delta_N (1-c_l)^2 + \Delta_1 (c_l - c_l)^2 + \Delta_2 [c_l - (c_l + c_2)]^2 + \Delta_3 (c_l - 1 + c_4)^2 + \delta_2 (c_3 + c_4)^2 + \delta_3 c_4^2 + \frac{1}{3} (A_1 c_l^2 + A_2 c_l^2 + A_3 c_l^2 + A_4 c_l^2 + a_1 c_l^2 + a_2 c_l^2 + a_3 c_l^2 + a_4 c_l^2) + A_1 c_l (c_l - c_l) + A_2 c_l (c_l - c_l) + A_3 c_l (c_l - c_l) + A_4 c_l (c_l - c_l) + a_2 (c_2 + c_3) c_4$ $2. \delta' = \frac{1}{16} (\Delta_0 + 9\Delta_N + \Delta_2 + 4\Delta_3 + 4\delta_2 + \delta_3 + \frac{A_1 + A_2 + 7A_3 + 19A_4}{3} + \frac{a_1 + 19a_2 + 7a_3 + a_4}{3})$ $3. \delta' = \frac{1}{4} \left( \frac{\Delta_0 + 9\Delta_N}{4} + \frac{5\Delta}{4} + \frac{5\delta}{4} + \frac{7A + 7a}{3} \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| V    |                                | $m=1$ $n=4$ $N=5$ $1. \delta' = \Delta_0 c_l^2 + \Delta_N (1-c_l)^2 + \Delta_1 (c_l - c_l)^2 + \Delta_2 [c_l - (c_l + c_2)]^2 + \Delta_3 [c_l - 1 + (c_4 + c_5)]^2 + \Delta_4 (c_l - 1 + c_5)^2 + \delta_2 (c_3 + c_4)^2 + \delta_3 c_4^2 + \frac{1}{3} (A_1 c_l^2 + A_2 c_l^2 + A_3 c_l^2 + A_4 c_l^2 + A_5 c_l^2 + a_1 c_l^2 + a_2 c_l^2 + a_3 c_l^2 + a_4 c_l^2 + a_5 c_l^2) + A_1 c_l (c_l - c_l) + A_2 c_l (c_l - c_l) + A_3 c_l (c_l - c_l) + A_4 c_l (c_l - c_l) + A_5 c_l (c_l - c_l) + a_2 (c_2 + c_3) c_4$ $2. \delta' = \frac{1}{16} (\Delta_0 + 9\Delta_N + \frac{\Delta_1 + 9\Delta_2 + 49\Delta_3 + 121\Delta_4}{25} + 4\delta_2 + \delta_3 + \frac{31A_1 + 7A_2 + 79A_3 + 247A_4 + 511A_5}{3 \cdot 25} + \frac{a_1 + 19a_2 + 7a_3 + a_4}{3})$ $3. \delta' = \frac{1}{4} \left( \frac{\Delta_0 + 9\Delta_N}{4} + \frac{9\Delta}{5} + \frac{5\delta}{4} + \frac{35A}{12} + \frac{7a}{3} \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| VI   |                                | $m=1$ $n=5$ $N=5$ $1. \delta' = \Delta_0 c_l^2 + \Delta_N (1-c_l)^2 + \Delta_1 (c_l - c_l)^2 + \Delta_2 [c_l - (c_l + c_2)]^2 + \Delta_3 [c_l - 1 + (c_4 + c_5)]^2 + \Delta_4 (c_l - 1 + c_5)^2 + \delta_2 (c_3 + c_4 + c_5)^2 + \delta_3 (c_4 + c_5)^2 + \delta_4 c_5^2 + \frac{1}{3} (A_1 c_l^2 + A_2 c_l^2 + A_3 c_l^2 + A_4 c_l^2 + A_5 c_l^2 + a_1 c_l^2 + a_2 c_l^2 + a_3 c_l^2 + a_4 c_l^2 + a_5 c_l^2) + A_1 c_l (c_l - c_l) + A_2 c_l (c_l - c_l) + A_3 c_l (c_l - c_l) + A_4 c_l (c_l - c_l) + A_5 c_l (c_l - c_l) + a_2 (c_2 + c_3) c_4$ $2. \delta' = \frac{1}{25} (\Delta_0 + 16\Delta_N + \Delta_2 + 4\Delta_3 + 9\Delta_4 + 9\delta_2 + 4\delta_3 + \delta_4 + \frac{A_1 + A_2 + 7A_3 + 19A_4 + 37A_5}{3} + \frac{a_1 + 37a_2 + 19a_3 + 7a_4 + a_5}{3})$ $3. \delta' = \frac{1}{5} \left( \frac{\Delta_0 + 16\Delta_N}{5} + \frac{14\Delta}{5} + \frac{14\delta}{5} + \frac{13A + 13a}{3} \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| VII  |                                | $m=2$ $n=5$ $N=5$ $1. \delta' = \Delta_0 (c_l + c_2)^2 + \Delta_N [1 - (c_l + c_2)]^2 + \Delta_1 (c_l + c_2 - c_l)^2 + \Delta_2 [c_l + c_2 - (c_l + c_2)]^2 + \Delta_3 [c_l + c_2 - 1 + (c_4 + c_5)]^2 + \Delta_4 [c_l + c_2 - 1 + c_5]^2 + \delta_1 c_l^2 + \delta_2 (c_l + c_2)^2 + \delta_3 (c_4 + c_5)^2 + \delta_4 c_5^2 + \frac{1}{3} (A_1 c_l^2 + A_2 c_l^2 + A_3 c_l^2 + A_4 c_l^2 + A_5 c_l^2 + a_1 c_l^2 + a_2 c_l^2 + a_3 c_l^2 + a_4 c_l^2 + a_5 c_l^2) + A_1 c_l (c_l + c_2) + A_2 c_l (c_l + c_2) + A_3 c_l (c_l + c_2) + A_4 c_l (c_l + c_2) + A_5 c_l (c_l + c_2) + a_2 (c_2 + c_3) c_4$ $2. \delta' = \frac{1}{25} (4\Delta_0 + 9\Delta_N + \Delta_1 + \Delta_2 + 4\Delta_3 + \delta_1 + 4\delta_2 + \delta_3 + \frac{7A_1 + A_2 + A_3 + 7A_4 + 19A_5}{3} + \frac{a_1 + 7a_2 + 19a_3 + 7a_4 + a_5}{3})$ $3. \delta' = \frac{1}{5} \left( \frac{4\Delta_0 + 9\Delta_N}{5} + \frac{6\Delta}{5} + \frac{6\delta}{5} + \frac{7A + 7a}{3} \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| VIII |                                | $m=1$ $n=5$ $N=6$ $1. \delta' = \Delta_0 c_l^2 + \Delta_N (1-c_l)^2 + \Delta_1 (c_l - c_l)^2 + \Delta_2 [c_l - (c_l + c_2)]^2 + \Delta_3 [c_l - (c_l + c_2 + c_3)]^2 + \Delta_4 [c_l - 1 + (c_5 + c_6)]^2 + \Delta_5 (c_l - 1 + c_6)^2 + \delta_1 c_l^2 + \delta_2 (c_l + c_2)^2 + \delta_3 (c_3 + c_4 + c_5)^2 + \delta_4 c_5^2 + \frac{1}{3} (A_1 c_l^2 + A_2 c_l^2 + A_3 c_l^2 + A_4 c_l^2 + A_5 c_l^2 + A_6 c_l^2 + a_1 c_l^2 + a_2 c_l^2 + a_3 c_l^2 + a_4 c_l^2 + a_5 c_l^2 + a_6 c_l^2) + A_1 c_l (c_l - c_l) + A_2 c_l (c_l - c_l) + A_3 c_l (c_l - c_l) + A_4 c_l (c_l - c_l) + A_5 c_l (c_l - c_l) + A_6 c_l (c_l - c_l) + a_2 (c_2 + c_3) c_4$ $2. \delta' = \frac{1}{25} (\Delta_0 + 16\Delta_N + \frac{\Delta_1 + 16\Delta_2 + 81\Delta_3 + 196\Delta_4 + 361\Delta_5}{36} + 9\delta_2 + 4\delta_3 + \delta_4 + \frac{43A_1 + 13A_2 + 133A_3 + 403A_4 + 823A_5 + 1393A_6}{3 \cdot 36} + \frac{a_1 + 37a_2 + 19a_3 + 7a_4 + a_5}{3})$ $3. \delta' = \frac{1}{5} \left( \frac{\Delta_0 + 16\Delta_N}{5} + \frac{131\Delta}{36} + \frac{14\delta}{5} + \frac{26A}{5} + \frac{13a}{3} \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| IX   |                                | $m=2$ $n=5$ $N=6$ $1. \delta' = \Delta_0 (c_l + c_2)^2 + \Delta_N [1 - (c_l + c_2)]^2 + \Delta_1 (c_l + c_2 - c_l)^2 + \Delta_2 [c_l + c_2 - (c_l + c_2)]^2 + \Delta_3 [c_l + c_2 - 1 + (c_5 + c_6)]^2 + \Delta_4 [c_l + c_2 - 1 + c_6]^2 + \delta_1 c_l^2 + \delta_2 (c_l + c_2)^2 + \delta_3 (c_3 + c_4 + c_5)^2 + \delta_4 c_5^2 + \frac{1}{3} (A_1 c_l^2 + A_2 c_l^2 + A_3 c_l^2 + A_4 c_l^2 + A_5 c_l^2 + A_6 c_l^2 + a_1 c_l^2 + a_2 c_l^2 + a_3 c_l^2 + a_4 c_l^2 + a_5 c_l^2 + a_6 c_l^2) + A_1 c_l (c_l + c_2) + A_2 c_l (c_l + c_2) + A_3 c_l (c_l + c_2) + A_4 c_l (c_l + c_2) + A_5 c_l (c_l + c_2) + A_6 c_l (c_l + c_2) + a_2 (c_2 + c_3) c_4$ $2. \delta' = \frac{1}{25} (4\Delta_0 + 9\Delta_N + \frac{49\Delta_1 + 4\Delta_2 + 9\Delta_3 + 64\Delta_4 + 169\Delta_5}{36} + \delta_1 + 4\delta_2 + \delta_3 + \frac{277A_1 + 67A_2 + 7A_3 + 97A_4 + 337A_5 + 727A_6}{3 \cdot 36} + \frac{a_1 + 7a_2 + 19a_3 + 7a_4 + a_5}{3})$ $3. \delta' = \frac{1}{5} \left( \frac{4\Delta_0 + 9\Delta_N}{5} + \frac{59\Delta}{36} + \frac{6\delta}{5} + \frac{14A}{5} + \frac{7a}{3} \right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|      |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |